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ASSOCIATION OF FOOD SCIENTISTS
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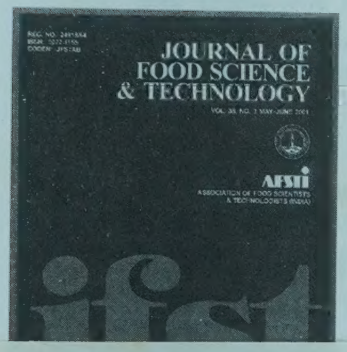

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REVIEW

J. Food Sci. Technol., 2001, Vol. 38. No. 6, 545-552

Deep-fat-frying of Foods - Its Significance on Nutrition and Health

SHUBHA SINGH AND V.K. TYAGI*

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A significant proportion of edible oils is used worldwide for deep-fat-frying for various foodstuffs. During repeated usage of oil, many reactions take place leading to the development of various types of decomposition products, which are supposed to be toxic from health point of view. The quality of oils also deteriorates nutritionally and the degree of deterioration depends primarily on the type of oil, its fatty acid composition, the type of food and the way it is being used for frying. The development of fast food centres further enhances the scope of deep-fat-frying because of the changing food habits of consumers. This important topic reviewed in this paper emphasises various aspects of deep-fat-frying, which has not touched upon in recent years.

Keywords : Oxidation, Hydrolysis, Polymerisation, Rancidity, Deterioration, Stability, Decomposed product, Polyunsaturated fatty acid, Nutritional value.

India is a country with vast population and about 70 % of her people are engaged in agriculture. Next to cereals, oilseeds are the most important crop. Most of the oils and fats from oilseeds produced in the country are consumed as food and fulfil specific nutritional requirement, thus playing an important role in Indian economy. They provide the highest source of energy to the body i.e., 1g fat produces 9.3 calories of heat.

India has the largest area under oilseeds cultivation, but ranks fourth in production (next to USA, China and Brazil) due to low per hectare world average yield and is the lowest among the major oilseed producing countries of the world (SEA 2000). India contributes about 10 % of the world's oilseed production. In terms of both income and availability, the per capita consumption of oil in our country has been quite low at about 8 kg, which is less than half of the world's average figures (SEA 2000).

The total import of the oil during 1998-99 was about 45.9 lakh tonnes, out of which 43.9 lakh tonnes were estimated to be for edible and 2.0 lakh tonnes were for non-edible purposes which were worth Rs. 9000 crore (SEA 2000).

The "Oil World" which is a world renowned journal from Germany has predicted that India may be importing 4.7-4.9 million tonnes of edible oil during 1999-2000 against 4.4 million tonnes at the end of the season.

A major portion of vegetable oils produced in this country is utilised for frying of food. Frying is an universal method employed for cooking food stuffs. Fried products or preparations form important items of food in the daily diets of people all over the world. There are various techniques of frying out of which deep-fat-frying and shallow frying are the most common. In shallow frying, the amount of frying medium is less than that of food to be fried and in deep-fat-frying, the food is completely immersed in large quantity of heated fat or oil. This method of food preparation is extensively used both at home and on commercial scale to enhance the organoleptic properties of food (Al-Kahtani 1991; Augustin and Berry 1983). Fried foods have always been popular items on the restaurant menu. The fast food centres, which have been going tremendously in recent years further increased the consumption of fried foods. It is predicted by various surveys that the deep-fried foods are very much relished and accepted by the people of all ages.

*Corresponding Author

Deep-fat-frying

Deep-fat-frying is more a technology than science. Deep-fat-frying can be defined as a process of control dehydration and browning with hot oils as the heat transfer medium. This involves both mass transfer and heat transfer (Gupta 1993). In deep-fat-frying, the food is totally immersed in the hot fat, where cooking is more efficient than dry heat of an oven and more rapid than boiling in water, due to higher temperature possible with deep-frying, resulting in more rapid penetration of heat into product being cooked (Stevenson et al. 1984).

The focus of frying is to produce high quality uniform fried food for immediate food service. The oil that is used to transfer heat energy is responsible for the delicious odour, flavour and texture associated with fried food (Thomson 1990; Swackhamer 1989).

During deep-fat-frying, the oil is continuously or repeatedly used at elevated temperature in the presence of air. During the course of heating, many reactions take place such as hydrolysis, oxidation, polymerisation, interaction between the fat and substrates. These reactions generate several volatile and non-volatile decomposition products, which are responsible for deteriorating the quality of the frying medium and are reported to pose health hazards (Crompton et al. 1953; Kaunitz et al. 1959; Perkins and Kummerow 1959). It is thus necessary to have an assured quality of frying medium during use to prevent excessive accumulation of the above mentioned undesirable products. Flavour, oxidative stability and fatty acid composition are important parameters for judging the quality of oil.

Process of deep-fat-frying

Summarized form of deep-fat-frying process is shown in Fig. 1. Food placed in hot oil is heated quickly to the point

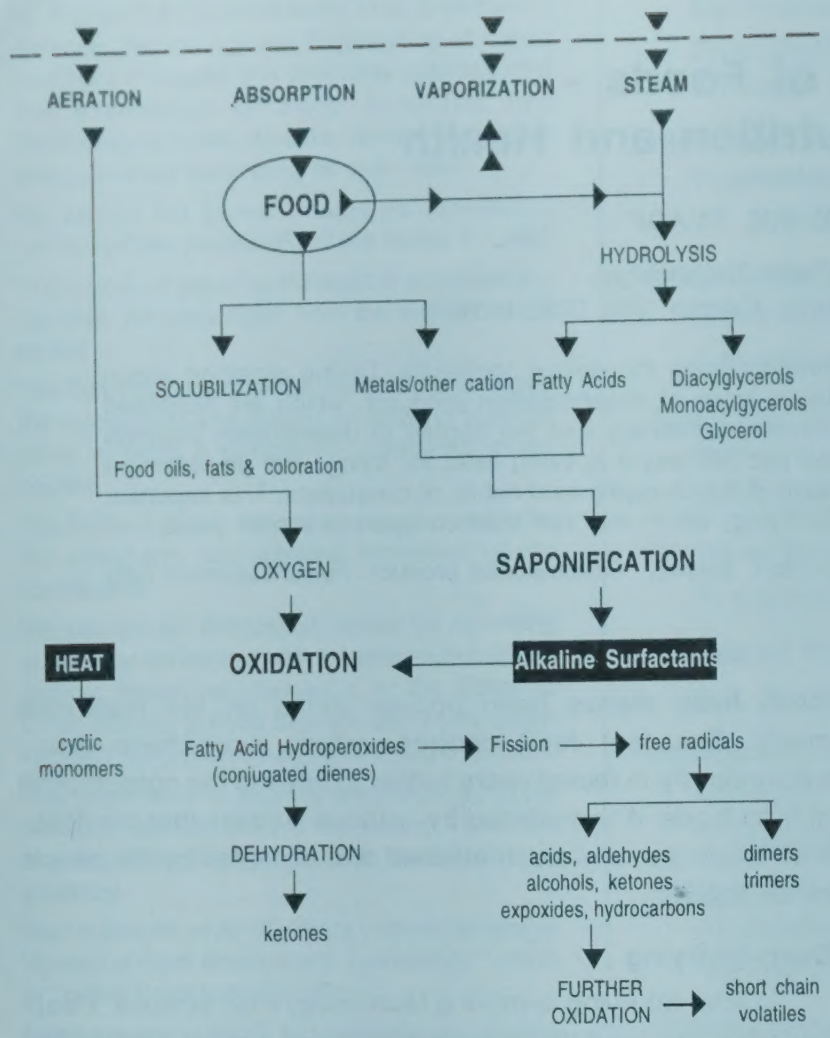

Fig. 1. Process of deep-fat-frying

where water is vaporized and the resulting steam causes the boiling action in the oil. This boiling action increases aeration in the oil, which results in increased oxidation of the oil with formation of hydroperoxides, the primary oxidation product. These peroxides are extremely unstable and decompose via fission, dehydration and formation of free radicals to form a variety of chemical products, both volatile and non-volatile decomposition products (VDP and NVDP). The volatile products are constantly being removed by volatilization, aided by evolving steam as well as being formed by continuing oxidation, hydrolysis and thermal or pyrolytic reactions. The NVDP formed mainly from the oxidation reactions may also be formed via the thermal or pyrolytic pathway. The NVDP consists mainly of polymers, dimers and trimers (Fritsch 1981). In general, those reaction products, with molecular weight greater than 18000 daltons are NVDP and those with molecular weight less than 18000 daltons are VDP (Rojo and Perkins 1987). Besides the degradation process in the oil, solubilization of components from food being fried, including colour compounds and food lipids also contribute to the heterogeneity of the frying oil and thus increase the rate of degradation.

The physical characteristics of the frying oil also change due to chemical reactions. The formation and accumulation of NVDPs are responsible for physical changes in the frying fat such as increase in viscosity, colour and foaming. The chemical changes include increases in free fatty acids (FFA), carbonyl value, hydroxyl content and saponification value and decrease in unsaturation with resulting increase in the formation of high molecular weight products (Perkins 1967).

Chemistry of deep-fat-frying and changes occurring in frying medium

Most of the fats contain oleic, linoleic acid and when these saturated fatty acids are treated at high temperature in the presence of air, the chemical changes occur through the mechanism of hydrolysis, oxidation and polymerisation of the frying medium, leading to the formation of NVDP. Factors that influence the proportion of break-down components in vegetable oils are temperature, presence and extent of oxygen, amount of moisture in the food, heating time, frying capacity, turn over method of heat transfer, metals in contact with the oil etc.

Hydrolysis

Food continuously releases moisture into the oils during frying and bring about the hydrolysis of fat causing increased acidity due to initial formation of free fatty acids, mono and diglycerides and glycerol. Soaps of some fatty acids are also formed and these accelerate degradation of frying medium (Podmore 1993).

$$\begin{array}{l} CH_2OCOR' \\ | \\ CHOCOR'' \\ | \\ CH_2OCOR''' \end{array} + 3H_2O \rightleftharpoons \begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array} + R'COOH + R''COOH + R'''COOH$$

Oxidation

Release of moisture, elevated temperature and exposure of oil to atmospheric oxygen during frying favour oxidation of the frying medium. Several products like hydroperoxides, aldehydes, ketones, lactones, hydrocarbons, alcohols, acids and polymeric compounds are formed. The product undergoes fission and forms smaller molecules which cros--link together to form monomers and dimers. Non-polymeric polar compounds e.g. hydroxy-and epoxy-acids are also produced, which are harmful to human health. Antioxidants, both synthetic (BHA, BHT and TBHQ) and natural (tocopherol) have been used in oil to extend their shelf life. About 7-50 % tocopherol naturally present in the oil is lost during repeated frying operation. (Gordon and Kourimska 1995). Oxidation may be autooxidation or thermal oxidation.

(i) Autooxidation : The reaction of atmospheric oxygen with fat molecules at room temperature is known as auto-oxidation.

When oil containing linoleates or other unsaturated fatty acids are oxidised, conjugated diene concentration increases at about the same rate as oxygen uptake and peroxide formation. The mechanism of autooxidation of ethyl linoleate originally proposed by Bolland and Koch (1945) is given in Fig 2.

(ii) Thermal oxidation : The process taking place when oil is heated at high temperature in the presence of oxygen is termed as thermal oxidation.

The complex reactions taking place in thermal oxidation of fats results in many chemical changes. Unsaturation decreases during heating; the proportion of non-conjugated acids decreases and the conjugated acid content increases to the maximum and finally it is destroyed. The carbonyl oxygen content increases during heating, showing that oxygen is chemically incorporated into the oil. FFA increases due to

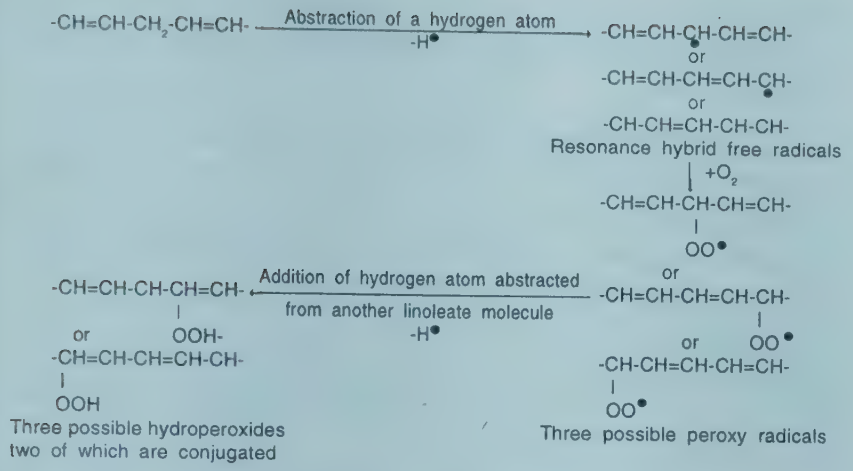

Fig. 2. Mechanism of autooxidation of ethyl linoleate

cleavage and oxidation of double bonds and also on account of this, saponification value increases. The polymeric products formed raise the viscosity of the oil. The high molecular weight product formed during frying decreases the nutritive value of the fat. Repeated heating and cooking process increases the deterioration of fat. Highly unsaturated oils form a multiplicity of compounds, when they are heated.

Polymerisation

Due to oxidation and thermal alteration, products undergo polymerisation forming gums and resins. When fat is heated to high temperature in the absence of oxygen, thermal polymerisation occurs. Thermal polymerisation of an unsaturated oil also yields cyclic monomers, dimers, trimers and even higher polymers. The rate of polymerisation increases with increasing unsaturation of the triglycerides and frying time (Artman 1969). The linoleic acid present in the fat is conjugated by heat. It may then cyclise within itself or another molecule containing a double bond to form a six membered cyclic compound. The double bond of cyclohexane ring reacts with conjugated linoleate to form a trimer. This mechanism is established through Diels-Alder (1928) reaction (Fig. 3).

Polymerisation of monoesters of polyunsaturated acids involve two successive Diels-Alder reactions, first forming a dimer and then forming a trimer.

Thermal polymerisation of ethyl linoleate can be depicted by the following sequence of reactions (Fig. 4).

These reactions bring about some changes like increase in viscosity, development of dark colour, decrease in iodine value and surface tension and an increased foaming tendency of oil (White 1991). Polymerisation reactions also lead to an increase in density. Viscosity of oil is affected by the frying time, temperature of oil and polymerisation reactions (Gutierrez et al. 1985).

Morphology of deep-fried products

The deep-fat-frying of a product results in distinctive structure. The upper part of the product is outer zone surface that results in crust and inner zone is core. (Fig. 5).

The upper most zone takes uniform golden brown colour in frying resulting in browning reaction or Maillard reaction which occurs when the sugar and protein present in the product react in the presence of heat. The degree of colour

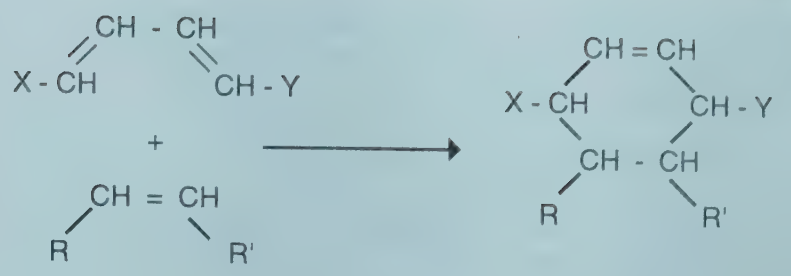

Fig. 3. Diels-Alder reaction

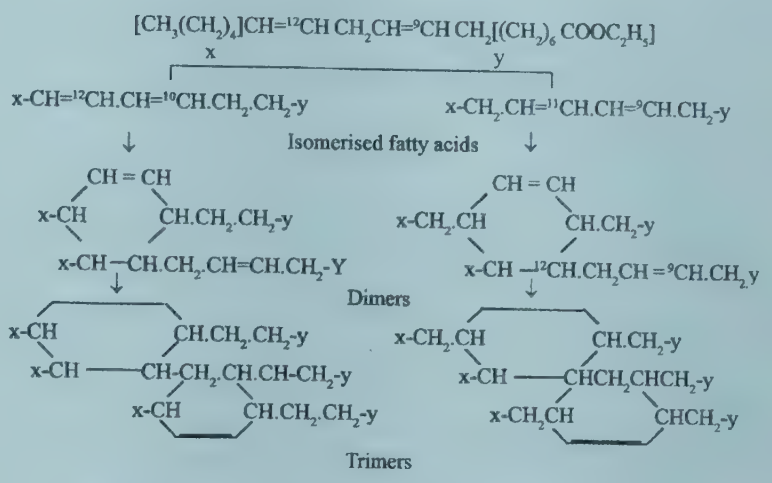

Fig. 4. Sequence of reactions to thermal polymerisation of ethyl linoleate

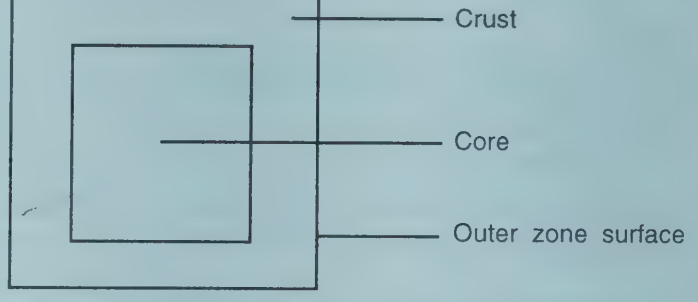

Fig. 5. Morphological structure of deep-fat-fried product

development depends on the time and temperature of frying and on the composition of the surface involved.

Crust formation is closely associated with fat distribution in the fried foods (Varela 1988). Another important phenomenon is that oil tends to concentrate more near the edges, corners and broken "slots" in the fried products. Polymers present in the frying oil are preferentially absorbed on the crust surface and in the outer layers. This layer contains much more oxidised, polymerised and carbonised oil fraction than the frying medium (Saguy and Pinthus 1995).

The outer zone crust or chips exterior skin is formed on the food surface by dehydration during frying. The void created by this loss of moisture is filled largely by absorption of the frying fat. This absorbed fat exerts a tendering effect on the fried food.

The inner zone or core is cooked moist interior. The cooking of this zone is due to heat penetration. Flavour and texture changes are affected here more by the effect of heat on the foodstuff accompanied with fat absorption.

Initially, the food material was considered to be homogenous and isothermal. Separate mathematical expressions were developed to describe heat and mass transfer

in the core and crust regions (Farkas et al. 1995). The following four second-order partial differential equations constituted the model.

Heat transfer in core region :

$$K'' \frac{\delta^2 T}{\delta x^2} + N_{\beta x} C_{\rho\beta} \frac{\delta T}{\delta x} (\varepsilon\beta\rho\beta C_{\rho\beta} + \varepsilon\sigma\rho\sigma C_{\rho\sigma}) \frac{\delta T}{\delta t}$$

Heat transfer in crust region :

$$(\varepsilon\gamma\rho\gamma C_{\rho\gamma} + \rho\sigma\varepsilon\sigma C_{\rho\sigma}) \frac{\delta T}{\delta t} = K' \frac{\delta^2 T}{\delta x^2} + N_{\gamma x} C\rho\gamma \frac{\delta T}{\delta x}$$

Mass transfer in core region :

$$\frac{\delta C_\beta}{\delta t} = D_{\beta\sigma} \frac{\delta^2 C_\beta}{\delta x^2}$$

Mass transfer in crust region :

$$\frac{\delta}{\delta x} = [\rho\gamma \frac{\delta P_\gamma}{\delta x}] = 0$$

Subscripts

β = Liquid phase

γ = Vapour phase

σ = Solid phase

o = Initial condition

Symbols

C_β = Concentration of $\beta = \varepsilon\beta\gamma\beta$ (kg/m^3)

P = Pressure (P_a)

t = Time (sec.)

T = Temperature (°C)

D = Diffusivity

Components of frying

There are several basic components of the frying system. These are the oils, the food and the equipment, which include the fryers, filters, ventilators, fryer feed and others.

Fryer : A fryer is an integral part of a whole system. There are two types of fryer, batch and continuous. The manufacture of fryer is based on the amount of food that is to be fried and the type and condition of food. The recommended construction metal for frying is stainless steel (Stevenson et al. 1984).

An industrial fryer exist for both batch and continuous systems; several basic components of frying equipments are:

(i) Oil holding kettle; (ii) Conveyor system; (iii) Heating and control system; (iv) Hood and canopy; (v) Hoist system; (vi) Filter/treatment system and (vii) Frying vessel.

Selection of frying medium

The selection of oil to be used for frying plays an important role in frying process. These include vegetable oils, animal-vegetable oil blends and margarine or shortening. The important criterion for the selection of an appropriate oil for frying is its stability which is related to fatty acid composition. The highly saturated fatty acids are less desirable nutritionally and also show adverse effect on human health (Cuesta et al. 1995). Besides these, price and availability are the major consideration in the selection of frying media (Tyagi and Vasishtha 1994).

Since the lipid composition of the fried food is thought to be an important factor at the time of frying, according to Kochhar (2000), appropriate criteria for the fatty acid composition of such a healthful frying oil are considered to be as. (i) It should be rich in monounsaturated, $C_{18:1}$ (>75 %); (ii) It should be low in saturated ($C_{16:0}$, $C_{14:0}$, $C_{12:0}$) and polyunsaturated fatty acid (<15 %); (iii) It should very low in linolenic acid, $C_{18:3}$ (<1.5 %), and (iv) It should have practically zero content of trans fatty acids.

It is commonly accepted among nutritionalists that when the requirement of essential fatty acids (EFAs), n-3 and n-6 fatty acids on body, dietary lipids rich in mono-unsaturated fatty acids, such as $C_{18:1}$ are beneficial to the oxidative stability of low-density lipoprotein (LDL) component of serum lipids.

According to some workers, a good frying oil should have the following features (Lawson 1985): (i) It should not contribute to "off-flavour" in the food; (ii) The good oil should retain long frying life from economical point of view; (iii) It should have appetizing golden brown, non-greasy surface on fried food; (iv) it should be resistant to excess smoking after continuous use; (v) It should have the ability to produce food with excellent taste and texture; (vi) It should be resistant to gumming that is formation of polymers; (vii) It should be resistant to rancidity; (viii) It should produce uniform quality fried products; (ix) It should be easy to use, which includes both forms (fluid and solid) and packaging; (x) The product should be of good quality, imbibing least amount of oil/fat and (xi) A good oil should give expected, specific product "textures".

The quality of the oil as a frying medium is directly related to the quality of the food produced. Blumenthal (1991) illustrated the five stages of oil during the degradation and on this basis he had drawn a curve as shown in Fig. 6. This curve has been further modified by Paul and Mittal (1997) and again modified by Subramanian et al (2000).

The frying oil quality shows the relation between five stage of dehydration of oil and food quality (Blumenthal and 1991).

1. Zone OA-Break in oil : This is the initial stage when product is white, raw, ungelatinized starch at center of fry. There is no cooking order, no crispness on surface. Only food starts to pick up little amount of oil.

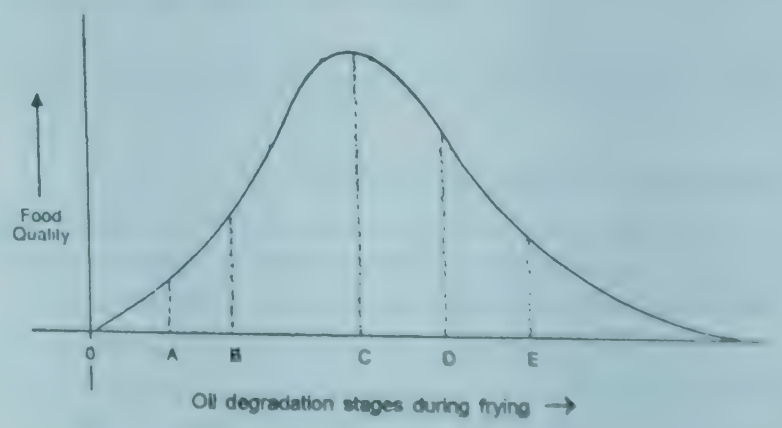

Fig. 6. Frying oil quality curve

2. Zone AB - Fresh oil : Food's surface become slight brown, now it is partially fried and crispy at the edge and slight more absorption of oil takes place.

3. Zone BC - Optimum oil : At this stage, the colour of fried product is golden brown. Now it is cooked, crisp, the surface is hard. It gives delicious odour. The food absorbed optimum level of oil.

4. Zone CD - Degrading oil : The products produced in this stage become darker or spotty and having hard surface. The food is not crisp and shows limpness. The viscous, dark oil adheres on the surface of the food.

5. Zone DE - Runaway oil : This is the stage when the frying oil should be discarded because now the center of the food is not fully cooked, also gives off-flavour and off-odour. And now the viscous oil shows greasy surface over the fried food.

Quality control tests for degraded frying oil

The changes occurring in oil during deep-fat frying are complex and variable, producing numerous types of decomposition products and altering the functional, sensory and nutritional qualities of frying oils. There are several controls at the fryer operator's disposal to keep the rate of oil decomposition minimum and reduce the breakdown of product through good frying practice, which is important for extending the frying life of oil. But, even then, there is a limit for repeated use of oil for frying. There are several parameters for measuring oil deterioration during frying.

Methods	References
Physical characteristics of oil	
Colour (method Cc13c-50)	AOCS (1983)
Smoke point (method 9a-48)	AOCS (1983)
Viscosity	Stevenson et al (1984)
Foam height	Fritsch et al (1979)
Unstable/Volatile decomposition products	
Conjugated dienoic acid (method Ti 1a-64)	AOCS (1983)
Free fatty content (method 28.032)	AOAC (1984)
Peroxide value (method Cd-8-53)	AOAC (1984)
Carbonyl content	Linow et al (1966)
Acid value (method Cd 2.201)	IUPAC (1987)
Volatiles (Gas liquid chromatography)	Jacobson et al (1989)
Non-volatile decomposition products	
Polar components (method 28.074)	AOAC (1984)
Fatty acid analysis (method Ce 1-62)	AOCS (1983)
Iodine value (method 28.023)	AOAC (1984)
Non urea-adduct forming esters	Alim and Morton (1974)
Cyclic monomers	Rojo and Perkins (1987)
Hydroxyl value (method Cd 4-40)	AOCS (1983)
Petroleum ether insoluble oxidized fatty acids	Billek et al (1978)
Alkaline contaminant material	Blumenthal and Stockler (1986)
Epoxy resin	Franzke et al (1969)
Dielectric constant (food oil sensor)	Graziano (1979)

Several researches had been carried out related to deep-fat frying. Blumenthal (1976) studied the effect of oil/fat on flavour of deep-fried food. Guillaumin (1977) subjected sunflower, soybean, peanut and palm oils at 220°C for 15 days and found them increase in percentage of new chemical species derived from fatty acids. Augustin et al (1987) evaluated the measurement of fat deterioration during static heating with intermittent frying of potato chips and found significant linear relationship between iodine value, $C_{18:2}/C_{16:0}$ ratio, polar component and dielectric constant. Hawrysh et al (1990) determined the efficacy of TBHQ and BHA/BHT treated canola oil deep-fried at 180°C and found that neither TBHQ nor BHA/BHT was effective in enhancing the thermal stability of the oil. Sen and Sen (1993) studied the oxidised fatty acid content of heat damaged frying oils and Indian deep-fat-fried products. Tyagi and Vasishtha (1994) evaluated the quality of frying oils on the basis of losses of poly-unsaturated fatty acids using RBD soybean oil and vanaspati as experimental oils at the temperature of 170°, 180° and 190°C and found antioxidants ineffective in reducing the losses of PUFA in frying operations. Dobarganes (1995) measured the distribution and quality of polar compounds and altered fatty acids in used frying oils. Tyagi and Vasishtha (1996) studied that polyunsaturated fatty acids decreased in direct proportion of frying time and temperature and found that levels of non-urea adduct forming esters were proportion to the losses of unsaturated fatty acids. Farid and Chen (1998) analysed heat and mass transfer during frying of food using the heat conduction equation. Che Man and Tan (1999) made the comparative study of the effect of anti-oxidants on the changes in quality characteristics of RBD palm olein during frying. There was no significant difference in sensory evaluation for rancid odour during storage periods.

Based on all these researches, it was concluded that polar materials could be an excellent predictor of food quality for many operations. Pokorony (1984) demonstrated that increase in the polar fraction resulted in an eventual decline in food quality. Several workers believed with a concentration of 25-27 % total polar component, a frying oil is considered as deteriorated and should be discarded. According to Federal Republic of Germany recommendations frying fat is considered to have deteriorated if : (a) odour and flavour are definitely not acceptable, (b) the concentration of petroleum ether insoluble oxidised fatty acid is 0.7 % or higher and the smoke point is lower than 170°C or (c) the concentration of petroleum ether insoluble oxidised fatty acid is 1 % or higher (Billek et al. 1978). A level of petroleum ether insoluble oxidised fatty acid be 0.7 % which is equivalent to threshold range of polar components.

Nutritional and safety aspects of frying fats and oils

Nutrients provide energy, promote body growth, maintain and repair body tissue, promote reproduction and lactation and regulate body process. Fats are the major sources of energy and are carriers of fat soluble vitamins. They also stimulate caloric intake and increase growth rate and physical performance.

It is well established that heating of fat results in formation of compounds with antinutritonal properties. These compounds may be enzyme inhibitor, vitamin destroyers, lipid-oxidation products, gastro-intestinal irritants and/or potential mutagens. Excess stress on fats leads to toxic substances. Feeding over heated fats and oils in animal leads to weight loss, suppression of growth, hair loss, diarrhoea, skin problems and in extreme cases even death (Clark and Serbia 1991).

Effect of frying on nutritional quality of potato chips

Fried foods are the healthy component of the diet. Potato chips contain twice as much vitamin C and five times as much fibres as apples. Protein digestibility change is very little after frying, while net protein utilization is not altered. Vegetable oils used in the preparation of fries, are one of the richest sources of vitamin E, yet they vary considerably in α-tocopherols (0-125 mg/100g) (IFT scientific status summary 1979; Herting and Drury 1963; Hunter 1981). Tocopherols are reduced gradually in used oils over several days use. There is a moderate loss of the essential amino acid lysine (11-24%) though this rises when thermally abused oil is used. Ascorbic acid is retained better during frying than during roasting. Prolonged use of frying oil in a food-serve operation resulted in both a significant decrease in vitamin C and a significant increase of fat in the product. Losses of vitamins E and C should be considered since they may be extensive in deep-fat frying. Although there is some loss of vitamin E, fried potatoes remain a very important source of vitamin E. Absorbed fats perform two useful functions, one is tenderizing the crust and other one is wetting of fried foods, both of which enhance the eating enjoyment.

Hazards of consuming the repeatedly heated oil and care taken by the commercial fryers

Heating of fats under actual frying conditions causes the formation of toxic substances. But the level of such compounds was so low that they have no dietary significance. Some compounds are extremely toxic that are the cyclic monomers and fractions containing the non-urea adduct forming fatty acids (Bailey's 1996). The German health authorities received a number of reports of several persons who are suffering from gastro intestinal distress after consuming foods fried in repeated used oils in restaurants. Heated oils are also the insidious cause of carcinogenic and coronary heart diseases. Deteriora-ted oils not only have an adverse affect on human nutrition but also have poor texture, flavour and flavour stability of the fried foods. To take care of this, commercial fats should add some oil stabilizers. The absorbants based on expanded perlite containing both water and citric acid have the special ability to remove soapy surfactant products in oils from deep-fat fryers. They also remove free fatty acids, polar fractions and polymeric compounds and extend the frying life of the oil.

Development and improvement of deep-frying fats

The trend of consumption of fats is shifting from saturated fats towards various oils rich in polyunsaturated fatty acids (PUFA). These oils are graded superior in nutritional values because of the presence of significant amount of PUFA therin and inferior because of their poor oxidation stability.

Because of health and nutritional factors, oils and such food products are receiving much attention. It is important to formulate new vegetable oil composition of improved stability and nutritional value (Frankel and Huang 1994). These oils can be modified either by blending of a suitable oil in an appropirate ratio or by interesterification of these oils and their blends and by adding some stabilizers.

Blending of oil is a good way to obtain a stable and nutritionally good frying medium and simultaneously provide scope for increased availability of high priced oil which are in short supply.

Several researchers have carried out studies, relating to oil blending. Stability of blended oil was first investigated by Millwalla and Subrahmanyam (1986). Wilhelm (1989) examined the oxidative stability and frying performance of butter oil, sunflower oil and olive oil blends. Vernin (1990) prepared PUFA rich oil blend with fish oil which have acceptable acidity and stability to oxidation. El-Shami (1992) compared the dielectric properties of the conventional method for evaluating the frying quality of a blend of cottonseed and sunflower oil. Handoo et al (1992) studied the properties of groundnut-cottonseed oil blends and evaluated organoleptic properties by taste panel. Handoo et al (1994) observed the storage properties of cottonseed-mustard and corn-mustard oil blends. Saha (1995) determined optimum ratio of saturated, monounsaturated and polyunsaturated fatty acids by blending of suitable oils. Warner (1997) determined the flavour and off-flavour in potato chips by the effect of fatty acid composition of commercially processed cottonseed and high oleic sunflower oil blends. Lakshmi and Sarojini (1998) tested the acceptability of blended oils i.e., red palm oil with groundnut oil in varying ratios for deep-fat frying. Tyagi et al (1998) performed frying experiments with soybean oil blended with raw mustard and sesame oil and reported that deterioration in soybean oil blended with mustard oil showed higher stability for frying. Tyagi et al (1999) used sunflower-groundnut oil blends for frying. Singh et al (1999) blended ricebran oil with safflower oil and deep-fried the potato chips. Singh and Tyagi (2000) determined the polar components generated in various frying oils to assess the extent of deterioration on their repeated uses during frying by silica-gel column chromatography. This method was found to be more reliable and accurate in assessing the rate of deterioration than any other conventional analytical methods.

Improving the economics of frying

The over-used or highly abused frying oil contains oxidised and polymerised materials which are harmful to human health. The decomposition product produced during frying are found to be toxic. The deep-fat fried products are the major items of diet in the world. It is absolutely essential for the research institute, commercial and industrial operators and government agencies to join forces to ascertain the safety wherein it does not show any adverse affect on human metabolism, and determine the point at which a batch of oil must be discarded

Waste vegetable oils from deep-frying process have been successfully used (in combination with diesel) as a fuel in diesel engines (Lague et al. 1988). Such industrial uses and investigations into them would greatly improve the economics of the frying process in totality.

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RESEARCH PAPER

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Effect of Storage Temperature and Folds of Concentration on Quality Characteristics of Galgal (*Citrus pseudolimon* Tan.) Juice Concentrates

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Galgal (*Citrus pseudolimon* Tan.) juice concentrates of various degrees Brix (45°, 60° and 70.5°B) were prepared using rotary type vacuum evaporator (55 ± 2°C and 28 ± 2" Hg vacuum). Storage studies on these products indicated that all concentrates stored up to six months experienced slight increase in total solids (2.27 %), reducing sugars (1.22 % dwb), hydroxymethyl furfural (16.75 times) and non-enzymatic browning (3 times) and a consistent decline in ascorbic acid (50.29 % dwb). However, the changes in physico-chemical and sensory qualities were comparatively less in concentrates stored under refrigerated conditions (3-7°C) than those stored at room temperature (13.3 - 26.3°C). Further, the retention of quality attributes during storage was better in juice concentrate of 45°B than the concentrates of higher folds.

Keywords : Galgal, (*Citrus pseudolimon* Tan.), Juice concentrate, Vacuum evaporation, Storage, Physico-chemical, Sensory quality.

Galgal (*Citrus pseudolimon* Tan.) also known as "Hill Lemon" is a local cultivar of lemon grown extensively in the plains and sub-mountainous regions of North-Western Himalayan ranges of the country including Himachal Pradesh, Punjab and some parts of Uttar Pradesh. Galgal trees are prolific beares and have very high productivity as compared to other citrus fruits. Out of total production of 3167000 tonnes of citrus fruits in India, limes and lemons alone account for about 30.94 % (FAO 1998). Further, in Himachal Pradesh as against 8.31 % of the total area, the share of Hill Lemon in the production constituted about 22.42 % among all citrus fruits druing 1998-99 (Anon 1999). The nutritional value of this fruit lies in its high contents of acidity, ascorbic acid, minerals and flavonoids (Swisher and Swisher 1977; Sharma 1996). However, it fetches a very low market price owing to its very limited and seasonal utility in the preparation of some pickles and squashes. Preparation of juice concentrate is an important alternative for utilizing the high acid contents of the juice in preparation of various products. The present investigations were therefore made to standardize the optimum level of concentration and to study the changes in important quality attributes of juice concentrates during storage.

Materials and Methods

The juice of galgal fruits harvested at optimum maturity from private orchards in district Sirmour (Himachal Pradesh) was extracted using rosing machine. The juice after heat pasteurization at 90°C for 10 sec (Ting and Rouseff 1986) was then preserved in 500 ppm SO_2 and packed in glass bottles. Before concentration, the juice was clarified using 0.2 % pectinase enzyme for 2 h at 50 ± 2°C. The clarfied juice was then concentrated to 45°, 60° and 70.5°B concentration in a rotary type vacuum evaporator at a temperature of 55 ± 2°C and 28 ± 2" Hg vacuum. The prepared concentrates were then packed in hgih density polyethylene (HDPE) bottles (100 ml capacity) after uniform addition of 250 ppm SO_2 and stored up to six months at two different temperatures viz., room temperature (13.3 - 26.3°C and 44.5 - 81.0 % RH) and low temperature (3 - 7°C and 73 % RH) for conducting storage studies.

Analyses : The moisture, titratable acidity, ash and HMF (hydroxymethyl furfural) in juice concentrates were determined using the methods of AOAC (1984). Sugars (reducing and total), ascorbic acid and pectin in different samples were determined using methods as detailed by Ranganna (1997). While, colour and non-enzymatic browning of 2 % aqueous solutions of various concentrates were determined at 420 and 440 nm, respectively using Spectronic-20 spctrophotometer (Ranganna 1997).

For sensory evaluation, all the concentrates (45°, 60° and 70.5°B) reconstituted to original degree Brix (7.5°Brix) were converted to squashes without any exogenous addition of acid and flavour. The prepared squashes were then diluted in the ratio of 1:3 with chilled water prior to serving to the taste panelists (7-9 judges in each session) and evaluated for overall acceptability on the basis of colour, flavour, body and taste on a 9 point Hedonic scale (Amerine et al. 1965).

Statistical analyses : Triplicate determinations were made for each attribute and the data pertaining to the physico-chemical and sensory characteristics were analyzed using Completely Randomized Design and Randomized Block Design respectively (Cochran and Cox 1967).

Results and Discussion

The juice concentrates of all the three folds viz., 45°, 60° and 70.5°B experienced slight increase (mean 2.28 %) in total solids during storage at room as well as at low temperature (Table 1). Slight loss of moisture through HDPE bottles might have caused the resultant increase in total solids of the concentrates. All the juice concentrates showed slight decline in their acid contents (dwb) with the increase in period of storage. The changes in acid contents were less during low temperature storage than at room temperature. The change

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TABLE 1 EFFECT OF STORAGE ON TOTAL SOLIDS, TITRATABLE ACIDITY AND ASCORBIC ACID CONTENTS OF GALGAL JUICE CONCENTRATES

Temperature	Storage period, months	Total solids, % — Degree of concentration 7.50°B	45°B	60°B	70.5°B	Mean	Mean (S)	Titratable acidity, % — Degree of concentration 7.50°B	45°B	60°B	70.5°B	Mean	Mean (S)	Ascorbic acid, mg/100g — Degree of concentration 7.50°B	45°B	60°B	70.5°B	Mean	Mean (S)
RT-	0 Day	7.55	47.05	62.25	72.94	47.45	47.45	65.69	64.78	64.64	64.54	64.91	64.91	425.96	280.00	266.67	249.65	305.57	305.57
(13.3 — 26.3°C)		(15.95)	(43.31)	(52.09)	(58.65)	(43.54)	(43.54)												
	3	7.62	47.45	63.72	73.16	47.99	48.31	65.35	64.45	64.42	64.39	64.65	64.69	279.40	148.70	154.97	139.58	180.66	203.65
		(16.02)	(43.54)	(52.96)	(58.80)	(43.85)	(44.03)												
	6	7.69	47.59	63.88	73.54	48.17	48.53	65.02	64.34	64.31	64.11	64.44	64.52	172.04	103.49	95.88	92.67	116.02	151.89
		(16.09)	(43.62)	(53.06)	(59.04)	(43.95)	(44.16)												
	Mean	7.62	47.36	63.28	73.21	47.87		65.35	64.52	64.46	64.35	64.67		292.47	177.40	172.51	160.63	200.75	
		(16.02)	(43.49)	(52.70)	(58.83)	(43.78)													
LT-	0 Day	7.55	47.05	62.25	72.94	47.45		65.69	64.78	64.64	64.54	64.91		425.96	280.00	266.67	249.65	305.57	
(3 — 7°C)		(15.95)	(43.31)	(52.09)	(58.65)	(43.54)													
	3	7.68	48.35	63.96	74.57	48.64		65.49	64.53	64.49	64.42	64.73		341.28	204.45	180.66	180.17	226.64	
		(16.09)	(44.05)	(53.11)	(59.72)	(44.22)													
	6	7.72	48.75	64.44	74.67	48.89		65.28	64.41	64.37	64.36	64.60		293.65	161.74	150.74	144.97	187.77	
		(16.13)	(44.28)	(53.39)	(59.78)	(44.36)													
	Mean	7.65	48.05	63.55	74.06	48.33		65.49	64.57	64.50	64.44	64.73		353.63	215.40	199.36	191.60	240.00	
		(16.05)	(43.88)	(52.86)	(59.38)	(44.04)													
	Grand mean	7.63	47.70	63.41	73.63			65.42	64.54	64.48	64.39			323.05	196.40	182.93	176.11		
		(16.03)	(43.68)	(52.78)	(59.10)														

	$CD_{0.05}$	$CD_{0.05}$	$CD_{0.05}$
Concentration (C)	0.03	0.24	9.14
Temperature (T)	0.02	NS	6.46
Storage (S)	0.03	0.21	7.91
C x T	0.04	NS	12.93
T x S	0.05	NS	11.20
C x S	0.03	NS	15.83
C x T x S	0.06	NS	22.40

7.50° Brix represents single strength juice; Figures in the parentheses are arc sine transformed values used for statistical analysis. RT = Room Temperature; LT=Low Temperature

TABLE 2. EFFECT OF STORAGE ON REDUCING SUGARS, TOTAL SUGARS AND HYDROXYMETHYL FURFURAL CONTENTS OF GALGAL JUICE CONCENTRATES

Temperature	Storage period, months	Reducing sugars, % — Degree of concentration 7.50°B	45°B	60°B	70.5°B	Mean	Mean (S)	Total sugars, % — Degree of concentration 7.50°B	45°B	60°B	70.5°B	Mean	Mean (S)	Hydroxymethyl furfural, ppm — Degree of concentration 7.50°B	45°B	60°B	70.5°B	Mean	Mean (S)
RT-	0 Day	20.93	21.23	21.30	21.36	21.20	21.20	26.75	26.46	26.37	26.25	26.46	26.46	0.93	1.34	1.43	1.52	1.30	1.30
(13.3 — 26.3°C)	3	21.00	21.49	21.50	21.66	21.41	21.35	26.64	26.30	26.18	26.18	26.32	26.35	19.03	32.83	39.78	45.90	34.38	19.76
	6	21.06	21.60	21.63	21.86	21.54	21.46	26.53	26.26	26.14	26.06	26.25	26.29	20.67	35.97	43.19	49.72	37.39	21.76
	Mean	21.00	21.44	21.48	21.63	21.39		26.64	26.34	26.23	26.16	26.34		13.54	23.38	28.13	32.68	24.36	
LT-	0 Day	20.93	21.23	21.30	21.36	21.20		26.75	26.46	26.37	26.25	26.46		0.93	1.34	1.43	1.52	1.30	
(3 — 7°C)	3	20.96	21.30	21.43	21.47	21.29		26.69	26.37	26.27	26.20	26.38		1.56	5.36	6.21	7.47	5.15	
	6	20.98	21.49	21.49	21.60	21.39		26.68	26.29	26.21	26.18	26.34		1.94	6.34	7.40	8.86	6.13	
	Mean	20.96	21.34	21.41	21.48	21.30		26.71	26.37	26.28	26.21	26.39		1.48	4.35	5.01	5.95	4.19	
	Grand mean	20.98	21.39	21.44	21.55			26.67	26.35	26.25	26.18			7.51	13.86	16.57	19.16		

	$CD_{0.05}$	$CD_{0.05}$	$CD_{0.05}$
Concentration (c)	0.22	0.07	0.65
Temperature (T)	NS	0.05	0.46
Storage (S)	0.19	0.06	0.56
C x T	NS	NS	1.60
T x S	NS	NS	1.50
C x S	NS	NS	1.80
C x T x S	NS	NS	1.90

7.50° Brix represents single strength juice; RT = Room Temperature; LT=Low Temperature

in acid contents might be attributed to the chemical interactions between organic constituents of citrus juices/concentrates during storage. The loss in ascorbic acid (dwb) in different concentrates after six months of storage at room temperature was between 59.61 and 64.04 % against a loss of 31.06 and 43.47 % at low temperature (Table 1). Further, the storage of concentrates caused a slight increase in their reducing sugar contents (dwb) i.e. 0.62 to 2.34 % at room temperatures and 0.24-1.22 % at low temperatures (Table 2). While, total sugars (dwb) in all concentrates experienced decrease with the passage of storage time. The decline in total sugars in juice concentrates could be attributed to the involvement of sugars in browning reactions leading to the formation of hydroxymethyl furfural. The mean increase in HMF contents (dwb) of concentrates stored at room temperature was as high as 18 times, while low temperature storage caused only 3 times

TABLE 3. EFFECT OF STORAGE ON COLOUR AND NON-ENZYMATIC BROWNING OF GALGAL JUICE CONCENTRATES

Temperature	Storage period, months	Colour, OD_{420nm}* Degree of concentration 7.50°B	45°B	60°B	70.5°B	Mean	Mean (S)	Non-enzymatic browning, OD_{440nm}* Degree of concentration 7.50°B	45°B	60°B	70.5°B	Mean	Mean (S)
RT-	0 Day	0.01	0.14	0.25	0.35	0.19	0.19	0.01	0.04	0.06	0.08	0.05	0.05
(13.3 — 26.3°C)	3	0.03	0.31	0.50	0.70	0.38	0.31	0.02	0.10	0.16	0.23	0.13	0.14
	6	0.04	0.34	0.57	0.77	0.43	0.35	0.02	0.14	0.25	0.34	0.19	0.15
	Mean	0.03	0.26	0.44	0.61	0.33		0.02	0.09	0.16	0.22	0.12	
LT-	0 Day	0.01	0.14	0.25	0.35	0.19		0.01	0.04	0.06	0.08	0.05	
(3 — 7°C)	3	0.02	0.16	0.30	0.49	0.24		0.01	0.05	0.09	0.18	0.08	
	6	0.03	0.18	0.36	0.54	0.27		0.02	0.07	0.13	0.22	0.11	
	Mean	0.02	0.16	0.30	0.46	0.23		0.01	0.06	0.09	0.16	0.10	
	Grand mean	0.02	0.21	0.37	0.53			0.01	0.07	0.17	0.19		
				$CD_{0.05}$						$CD_{0.05}$			
	Concentration (C)			0.05						0.07			
	Temperature (T)			0.06						0.06			
	Storage (S)			0.04						0.05			
	C x T			0.01						NS			
	T x S			NS						NS			
	C x S			NS						NS			
	C x T x S			NS						NS			

7.50° Brix represents single strength juice; * OD of 2 % aqueous solutions

TABLE 4. EFFECT OF STORAGE ON RESIDUAL SO_2, PECTIN AND ASH CONTENTS OF GALGAL JUICE CONCENTRATES

Temperature	Storage period, months	Residual SO_2 (ppm) Degree of concentration 7.50°B	45°B	60°B	70.5°B	Mean	Mean (S)	Pectin (% Ca pectate) Degree of concentration 7.50°B	45°B	60°B	70.5°B	Mean	Mean (S)	Ash (%) Degree of concentration 7.50°B	45°B	60°B	70.5°B	Mean	Mean (S)
RT-	0 Day	433.00	283.43	275.30	261.00	313.18	313.18	1.59	1.57	1.56	1.55	1.57	1.57	4.77	4.76	4.75	4.74	4.75	4.75
(13.3 — 26.3°C)	3	336.55	221.22	216.73	212.87	246.84	258.49	1.57	1.56	1.55	1.54	1.55	1.56	4.76	4.75	4.75	4.74	4.75	4.75
	6	240.43	190.05	188.76	185.43	201.17	218.05	1.56	1.55	1.55	1.54	1.55	1.55	4.75	4.75	4.75	4.74	4.75	4.75
	Mean	336.66	231.57	226.93	219.77	253.73		1.57	1.56	1.55	1.54	1.55		4.76	4.75	4.75	4.74	4.75	
LT-	0 Day	433.00	283.43	275.30	261.00	313.18		1.59	1.57	1.56	1.55	1.57		4.77	4.76	4.75	4.74	4.75	
(3 — 7°C)	3	383.25	239.41	232.27	226.68	270.15		1.59	1.57	1.55	1.55	1.56		4.76	4.76	4.75	4.74	4.75	
	6	316.18	212.56	208.62	202.39	234.94		1.58	1.56	1.55	1.55	1.56		4.76	4.75	4.75	4.74	4.75	
	Mean	377.14	245.13	238.73	230.03	272.76		1.59	1.57	1.55	1.55	1.56		4.76	4.76	4.75	4.74	4.75	
	Grand mean	356.90	238.35	232.83	224.89			1.58	1.56	1.55	1.54			4.76	4.76	4.75	4.74		
				$CD_{0.05}$						$CD_{0.05}$						$CD_{0.05}$			
	Concentration (C)			5.14						NS						NS			
	Temperature (T)			4.12						NS						NS			
	Storage (S)			4.86						NS						NS			
	C x T			6.18						NS						NS			
	T x S			5.76						NS						NS			
	C x S			7.03						NS						NS			
	C x T x S			9.19						NS						NS			

7.50° Brix represents single strength juice

TABLE 5. EFFECT OF STORAGE ON THE OVERALL ACCEPTABILITY OF GALGAL JUICE CONCENTRATES

Tempe-rature	Storage period, months	Overall acceptability* Degree of concentration 7.50°B	45°B	60°B	70.5°B	Mean	Mean (S)
RT-	0 Day	7.83	8.33	7.50	7.17	7.71	7.71
(13.3—26.3°C)	3	6.50	6.50	6.00	5.50	6.12	6.79
	6	4.50	5.67	5.33	5.00	5.12	5.99
	Mean	6.28	6.83	6.28	5.89	6.32	
LT-	0 Day	7.83	8.33	7.50	7.17	7.71	
(3—7°C)	3	7.00	8.00	7.67	7.17	7.46	
	6	6.00	7.50	7.17	6.83	6.87	
	Mean	6.94	7.94	7.44	7.06	7.35	
	Grand mean	6.61	7.39	6.86	6.47		

	$CD_{0.05}$
Concentration (C)	0.41
Temperature (T)	0.29
Storage (S)	0.35
C x T	NS
T x S	0.50
C x S	0.71
C x T x S	0.99

*Sensory evaluation based on colour, flavour, body and taste
7.50° Brix represents single strength juice

increase in this attribute. Further, the effect of level of concentration on the formation of HMF during storage was also significant. The juice concentrates of higher folds i.e. 60° and 70.5° B experiencing significantly higher reduction in total sugars also showed correspondingly higher increase in HMF contents. Similarly, the level of concentration and temperature of storage also exerted its significant influence on the non-enzymatic browning of the concentrates (Table3). The juice concentrates stored at refrigerated temperature showed significantly lower value of absorbance at 440 nm for browning even after six months of storage. The colour intensity (OD 420 nm) of galgal juice concentrates showed a consistent increase with the progress in period of storage (Table 3). The colour absorbance values of various concentrates of 45°, 60° and 70.5°B after six months of storage at low temperature were 0.18, 0.36 and 0.54 as against initial values of 0.14, 0.25 and 0.35 respectively. While, those stored at room temperatures had colour absorbance values as high as 0.34, 0.57 and 0.77 respectively for the corresponding period of storage. Thus, the low temperature storage and concentration up to 45°B caused significantly better retention of colour and checked the extent of browning in the product up to six months of storage. Increase in browning during concentration and storage was probably attributed to the degradation of ascorbic acid and sugars, thus leading to formation of brown pigments as also reported by Clegg (1964) and Fontana et al (1993). The residual SO_2 in juice concentrates experienced decline during storage up to six months with the maximum loss under room temperature conditions (Table 4). Earlier, Sandhu et al (1985) also observed maximum losses of SO_2 in kinnow mandarin juice concentrates of different folds stored at higher temperature than at low temperatures. The storage of hill lemon juice concentrates at room as well as under refrigerated conditions, though underwent slight decrease in their pectin contents but did not show much change in their ash contents under both conditions of storage.

Sensory evaluation of drinks made from different concentrates indicated that the product stored at low temperature had better liking for colour/appearance and flavour than those stored at room temperature. Further, the product made from concentrate of 45° Brix reflected highest ranking for its overall acceptability on the basis of various sensory attributes including colour, flavour, body and taste (Table 5). While, those made from concentrates of higher folds (60° and 70.5° Brix) were rated inferior in sensory quality. The increased browning coupled with loss of flavour during concentration and storage at room temperature was probably attributed to this decrease in sensory quality.

The present study thus, indicated the suitability of utilizing galgal juice for the preparation of juice concentrate of 45° Brix. The low temperature storage of concentrates brought about minimum changes in various quality attributes.

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RESEARCH PAPER

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Kinetic Model for Osmotic Dehydration of Green Peas Prior to Air Drying

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Green peas were osmotically dehydrated in sodium chloride-water solutions at three concentrations (5, 10 and 17 % sodium chloride by weight) and three temperatures (20, 30 and 40°C). Movement of salt and water was modelled for water loss from and salt uptake by the green peas. Green peas were dipped in 10 % sodium chloride-water solution at 30°C for 30 min and air dried in a fluidized bed dryer. Colour, texture, flavour and overall acceptability scores indicated that the dehydrated product was organoleptically acceptable.

Keywords : Pricking, Blanching, Osmosis, Mass transfer, Modelling, Drying.

Pea (*Pisum sativum*) is an important legume, which is consumed in several forms. Fresh peas as such are highly perishable and also their availability is seasonal. The dehydrated peas are gaining popularity because they offer the advantages of greater shelf-life, palatability and convenience during transport and handing. To obtain a dehydrated product of high quality, the drying process should be such that it should allow effective retention of colour, texture, flavour, taste and nutritive value, comparable to fresh pea. The conventional air drying has failed to produce dehydrated peas of high shelf-life (Hand et al 1955). Drying air temperature of 70-80°C with pricking and blanching has been reported to be good for pea dehydration in fluidized bed dryer (Kanawade and Maharaj Narain 1993).

Osmotic dehydration is the process of water removal by immersing in water containing cellular solid in a concentrated aqueous solution. The main advantages of the process are : inhibition of enzymatic browning, retention of natural colour without addition of sulphites, high retention of volatile compounds during subsequent drying and low energy consumption. Osmotic dehydration as an intermediate step in air or vacuum drying of fruits and vegetables was studied (Flink 1980; Kim and Toledo 1987). Kinetics of dewatering and mass transfer properties during osmotic process have been investigated for apple (Ponting et al. 1966; Hawkes and Fink 1987; Conway et al. 1983).

Pea is an important legume in many countries and for its extension of shelf life, the osmotic concentration technique could be applied for green pea dehydration as well. The objectives of the present work were (i) to study the effect of temperature and sodium chloride solution concentration on mass transfer and (ii) to model the kinetics of osmotic concentration of peas in aqueous solution of sodium chloride.

Materials and Methods

Raw material pre-treatment : The study was conducted on "Arkel" variety, as that being the most commonly grown in India, suitable for making it as a dehydrated product (Khurdiya et al. 1972). The green pea pods were procured from the local market. The pods were shelled manually, graded to 9.3-10 mm size in Carter-Day grader, pricked once in hand pricking machine and blanched in hot water at 96°C for 2 min. The blanched peas were immediately cooled using cold water and spread on a cotton cloth for removal of surface moisture.

Kinetic studies : The green peas 200 g were dipped in sodium chloride - water solutions in glass beakers at three different concentrations (5, 10 and 17 % sodium chloride by weight) and three temperatures (20, 30 and 40°C) by maintaining a solid to liquid ratio of 1:3. The glass beakers were mounted on a constant temperature shaking bath. Movement of salt and water was monitored by analyzing the samples of green peas and solution at designated times of 0, 5, 15, 30 and 60 min. Each sample was analyzed for weight loss, moisture, salt contents of green peas and the solution by titration (AOAC 1984). All the experimental measurements were replicated three times.

Air drying : The pricked green peas were dipped in 10 % sodium chloride-water solution at 30°C for 30 min and further processed for air-drying in a laboratory fluidized bed dryer. A drying air temperature of 80°C and minimum air velocity of 10 min/sec was used in fluidized bed dryer which was required for fluidization. The sample was weighed at an interval of 10 min, till the weight became more or less constant. The dried samples were cooled and packed immediately in polythene bags.

Fresh green peas were also pricked, blanched and air-dried in fluidized bed dryer at 80°C air temperature used as control (Kanawade and Maharaj Narain 1993).

Sensory evaluation : The osmo-dehydrated peas were subjected to sensory evaluation. The evaluation was carried out by a panel of 10 judges of different age groups, having different eating habits. Different attributes viz., colour, texture, flavour and overall acceptability were rated on a 9-point Hedonic scale (BIS 1972), ranging from 1 (most undesirable) to 9 (most desirable).

The air dried peas were also assessed as reference sample (control) for comparison.

Results and Discussion

Kinetics of osmosis : The moisture loss and salt content were calculated by using following mass balance equations.

The moisture loss (ML) was the net moisture from green pea at time ø on an initial mass basis.

$$ML = \frac{Wi\ Xwi - Wo\ Xwo}{Wi\ Xwi} \times 100 \quad \ldots\ldots (1)$$

The dry matter gain in relation to salt content and hence the salt content (SG) was the net gain in total solid by the green pea on initial mass basis

$$ML = \frac{Wi\ (1 - Xwi) - Wo\ (1 - Xwo)}{Wi} \times 100 \quad \ldots\ldots (2)$$

where,

ML = Moisture loss (g water /100g initial mass of green pea); SG = Salt content (g/100 g initial mass of green pea); Wi = Initial mass of green pea, g; Wo = Mass of green pea after time 'ø', g; Xwi = Water content as a fraction of the initial mass of pea; and Xwo = Water content as a fraction of the mass of pea time 'ø'.

Typical experiment of kinetics of osmosis is shown in Fig. 1. It was observed that the rate of water removal and salt gain were maximum at the beginning of the process. The moisture and salt contents decreased gradually and finally approached equilibrium with length of contact time. The nature of kinetic curves indicated that moisture content of green peas approached equilibrium with the bath much faster than the salt content. It also indicated that salt uptake by green peas could be regulated by controlling the length of contact time. If it is desired that the salt content of green peas should not exceed 6 % weight, then the length of contact time with 10 % sodium chloride-water solution at 40°C temperature should be about 14 min. The moisture content of green peas at this point would be about 84 % by weight. On the other hand, if the contact time was continued up to 30 min, the salt content of peas would be 8 % and moisture content 82 % by weight.

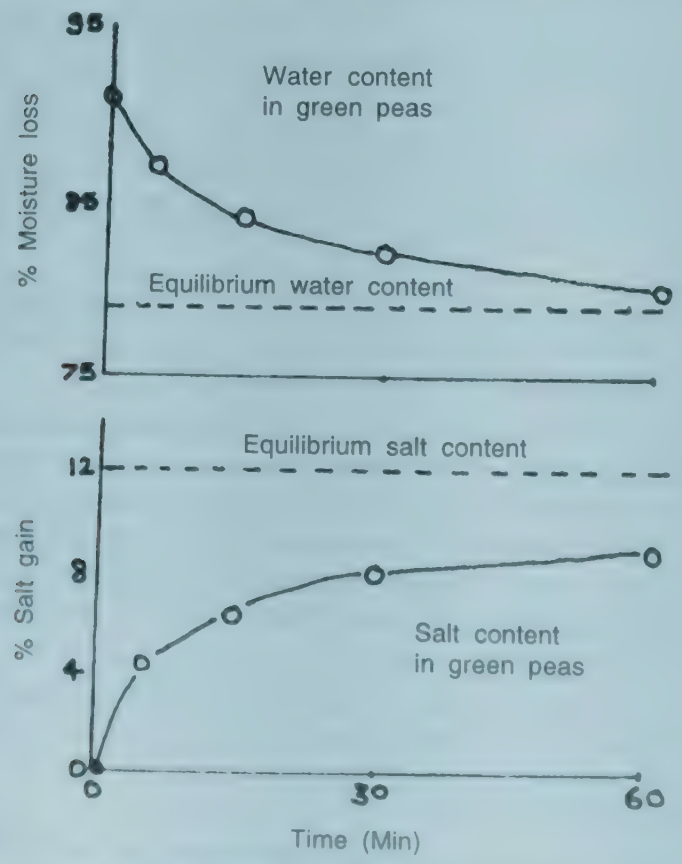

Fig. 1. Osmosis kinetics approach to equilibrium (Green peas in 17 % NaCl water at 40°C)

The kinetics of osmosis of all the experiments showed that the moisture loss and salt gain at any given temperature were affected greatly by initial concentration sodium chloride-water solution. Both moisture content and salt gain increased with increase in sodium chloride-water solution concentration (Co). On the other hand, at any given concentration (Co), the effect of temperature (t°C) on moisture loss and salt gain was very slight. Also, the effect of temperature on moisture and salt content in lower temperature range (20 to 30°C) was greater than in the upper temperature range (30 to 40°C). The moisture loss from and salt gain by peas at 40°C, for longer contact time was lower than at 30°C. This indicated that 40°C temperature was too high for green peas that might damage the cell membranes of green peas. Therefore, the modelling of moisture loss and salt gain should be between 20 and 30°C only.

Modeling of moisture loss and salt gain : In all the experiments, the moisture loss and salt gain increased with sodium chloride-water solution concentration and temperature. The resistance to movement of water from green peas into the solution lies in the solid. The moisture loss (ML), can be modelled on the principles of diffusion in solids. The green peas were considered as a half cylinder. Therefore, it was considered that the green peas soaked in limited volume of external solution (liquid: solid ratio at 3:1). The moisture loss (ML), essentially a concentration parameter, was proportional to the square root of contact time, in minutes (Crank 1975; Hawkes and Fink 1978; Pokharkar et al. 1997). Therefore, it could be written as

$$ML = Kw\ ø^{½} \quad \ldots\ldots (3)$$

where,

Kw = the mass transfer coefficient expressed as $(min)^{-½}$. The mass transfer coefficient "Kw" = function of Co, the starting NaCl - water solution concentration and contact temperature 't' °C. The mass transfer coefficient "Kw" was determined from the plot of the moisture loss verses square root of contact time 'ø' (Fig. 2) for three selected runs within

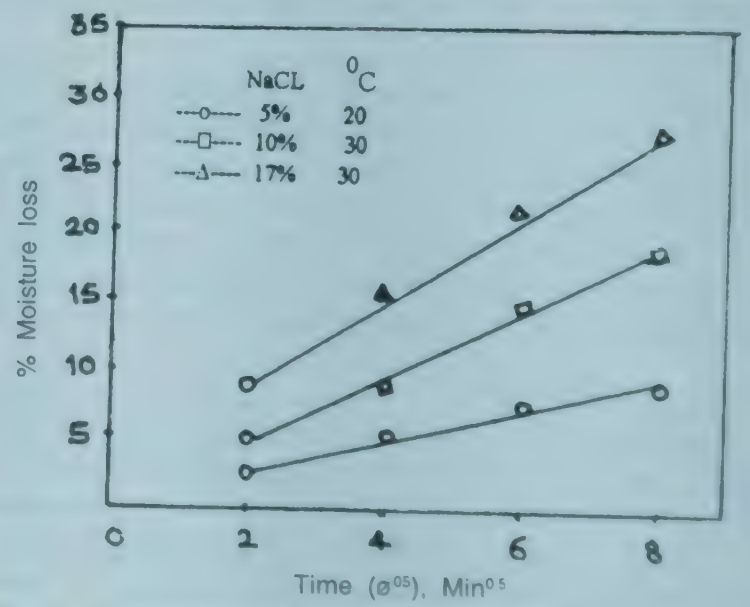

Fig. 2. Relationship of % moisture loss from green peas to square root of contact time

the range of concentrations and temperatures. The following model, similar to that of Magee et al (1983) was proposed for 'Kw'

$$Kw = A\ Co^{x}\ t^{y} \qquad \ldots\ldots (4)$$

where,

Co is the mass fraction of NaCl in a bath at time zero, g NaCl/g total solution and t = temperature of contact °C. The parameters A, x and y could be estimated from experimental data, as obtained through a non-linear regression. A = 0.086, x = 0.824 and y = 0.340 with an r^2 of 0.94. The equation for the moisture loss, therefore was :

$$ML = 0.086\ Co^{0.824}\ t^{0.340}\ \phi^{1/2} \qquad \ldots\ldots (5)$$

The salt gain 'SG (g sodium chloride /g of green pea) was modeled similarly to that of moisture loss.

$$SG = Ks\ \phi^{1/2} \qquad \ldots\ldots (6)$$

The mass transfer coefficient 'Ks' was determined from the plot of salt gain (SG) verses square root contact time (Fig. 3) for three selected runs within the range concentrations and temperatures. Equations (3) and (6) can be combined to give equation (7), which established a relationship between SG and ML.

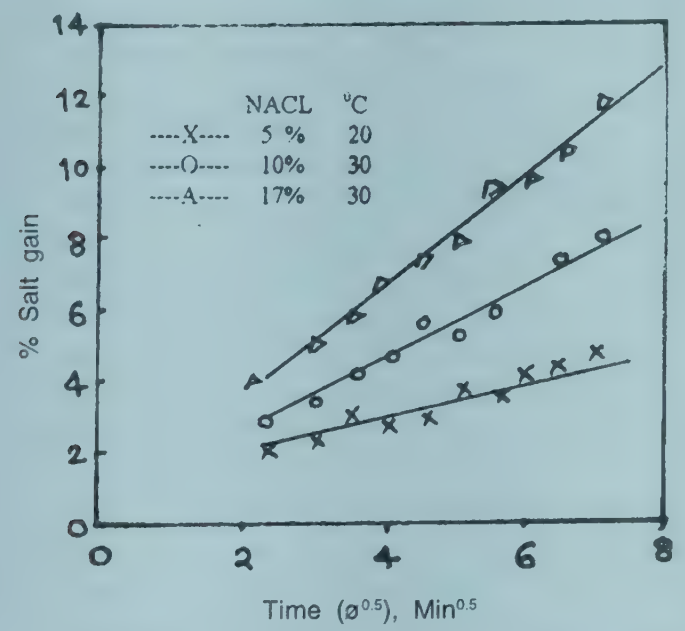

Fig. 3. Relationship of % salt gain by green peas to square root of contact time

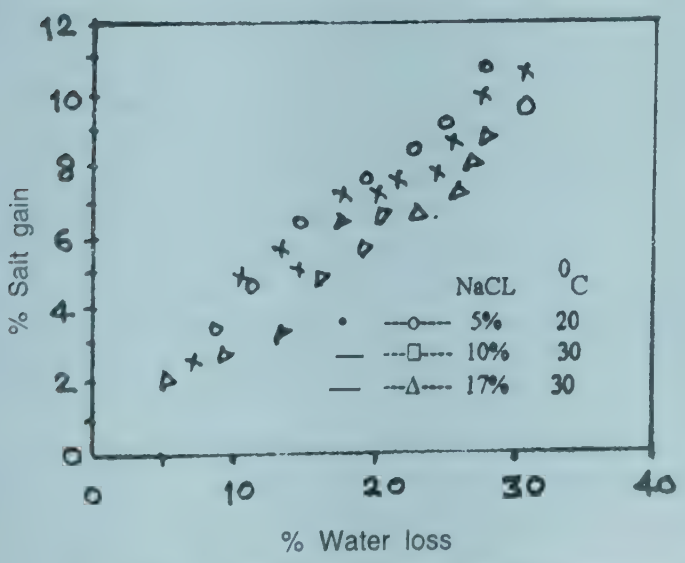

Fig. 4. Salt gain vs water loss during osmotic concentration

$$SG = \frac{(Ks)}{(Kw)} \times ML \qquad \ldots\ldots (7)$$

A plot of SG vs ML as shown in Fig. 4 indicates that although the cancellation of time effect ($\phi^{1/2}$) between SG and ML (Equation 7) tended to establish a linear relation between them, the residual effects of 'Co' and 't' introduced nonlinearity.

Using model similar to equation (4), 'Ks' the parameters obtained through a non-linear regression are given in equation (8) with $r^2 = 0.93$.

$$SG = 0.074\ Co^{0.820}\ t^{0.209}\ \phi^{1/2} \qquad \ldots\ldots (8)$$

As shown in Table 1, the predicted values of ML and 'SG' matched very well with experimental values.

Now, substituting for ML and SG from equation (5) and equation (8) respectively in equation (7), we may write :

$$Ks = Kw\ (2.23\ Co^{0.596}\ t^{0.131}) \qquad \ldots\ldots (9)$$

where,

$$Kw = 0.036\ Co^{0.624}\ t^{0.340}) \qquad \ldots\ldots (10)$$

The mass transfer coefficient, Kw and Ks for moisture and salt respectively were obtained from equation (10) and (9) respectively. The values of Kw and Ks were applied in equation (3) and (6) respectively, to yield the fraction of original moisture loss and salt content of green peas. From the practical application point of view, ML and SG as described by equation (5) and (8) respectively were not independent rather they were related to each other through equation (7). When the desired percentage of sodium chloride in green pea (SG) is specified, the required contact time, 'ø' for a given 'Co' and 't' is

TABLE 1. COMPARISON OF PREDICTED AND EXPERIMENTAL VALUES OF MOISTURE LOSS (ML) AND SALT GAIN (SG) AT CONSTANT TEMPERATURE 30°C

Sodium chloride water concentration (CO) Experimental	Time ø	Moisture loss (ML)		Salt gain (SG)	
		Predicted (Eq.5)	Experi-mental	Predicted (Eq.8)	Experi-mental
5	30	5.637	4.982	3.087	3.52
5	45	7.102	7.910	3.782	4.102
5	60	7.972	8.830	4.367	5.081
10	30	9.998	10.820	5.452	6.120
10	45	12.240	13.112	6.675	7.421
10	60	14.143	15.223	7.709	8.128
17	30	15.454	16.938	8.423	8.982
17	45	19.927	21.024	10.320	11.040
17	60	21.850	23.130	11.913	12.108

TABLE 2. SENSORY SCORE DATA FOR INDIVIDUAL CHARACTER

Characteristics	Mean sensory score		
	Air-dried peas, control	Osmo-dehydrated peas	
Texture	7.333	7.600	NS
Colour	7.266	7.200	NS
Flavour	6.066	6.866	S**
Overall acceptability	6.800	7.400	NS

calculated by equation (8). Then, the moisture loss (ML) at 'ø' may be calculated from either equation (5) or (7).

Effect of colour, flavour, texture and overall acceptability: The data on mean sensory score given by the judges for individual characteristics are presented in Table 2. It was observed that the pricking and osmotic concentration increases colour, texture, flavour and overall acceptability scores. Osmo-dehydrated peas were found to be non-significant in respect of texture, colour and overall acceptability and significant in respect of flavour at 5 % and 1 % level, respectively. This means that the osmo-dehydrated peas were rated excellent with the air dried peas.

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RESEARCH PAPER

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Improvement of Textural Quality of Layer Chicken Muscles by Calcium Chloride and Lactic Acid

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Influence of the solution of 0.15 M $CaCl_2$, 0.15 M lactic acid or their mixture (1:1) on tenderization of layer chicken muscles was studied using dip-treatment. The breast and thigh muscles from the left half of the carcass were dipped in solutions (1:1) for 65 h at the temperature of 2-4°C and the muscles from the right half of the carcass were held at 2-4°C (controls). The changes in water content, water holding capacity (WHC), pH and Instron firmness were measured in both treated and the untreated muscles. Absorption of chemical solutions resulted in an increase in water content and WHC of muscles. The $CaCl_2$ treatment decreased the muscle pH by 0.3 units whereas the treatment with lactic acid or the mixture of $CaCl_2$ and lactic acid decreased the muscle pH by 1.5 units. Breast muscles registered 20.2, 38.3 and 42.4 % and thigh muscles 21.4, 35.2 and 44.0 % lower Instron firmness values when treated with the solutions of 0.15 M $CaCl_2$ 0.15 M lactic acid or their mixture (1:1) respectively than the untreated (control) counterparts. The tenderizing effect of mixture of solutions was more pronounced than the effect of two solutions individually.

Keywords : Chicken muscles, Chemicals, Calcium chloride, Lactic acid, Dip-treatment, Tenderization.

Tenderness of meat is one of the major characteristics of eating quality affecting its acceptance by the consumer. Layer chickens after about 18 months of laying period, are sacrificed to produce meat. Meat from such aged chicken is tough and hence its use is limited to the preparation of comminuted meat products. Several attempts have been made to tenderize meat for further utilization. Treatment of muscles with chemicals such as calcium chloride ($CaCl_2$) and/or lactic acid, for possible tenderization is gaining importance in recent years. Use of these chemicals in meats has been approved by FDA as GRAS (generally recognized as safe) at maximum level of 3 % of an 0.8 M solution (FSIS 1973). Injection of $CaCl_2$ solution in ovine LD muscle (Whipple et al 1994), in spent hen muscles (Mendiratta et al. 1996, Woods et al. 1997) and in beef muscles (Wheeler et al. 1992) produced tenderizing effect. However, injection of lactic acid solution produced increased WB shear force values (Ertbierg et al. 1995) and decreased shear values (Stanton and Light 1990) in bovine muscles. Eilers et al (1994) observed 35 % reduction in shear values when beef muscles were injected with equal volumes of 0.3 M $CaCl_2$ and 0.3 M lactic acid. The drawback of injection method is its non-feasibility in commercial situation where thousands of birds are slaughtered and dressed. These researchers used the chemicals in the concentration range of 0.1-0.3 M for injection treatment. Dipping of carcasses/muscles in chemical solutions is a more feasible option. In the present study, 0.1, 0.15 and 0.2 M $CaCl_2$ and lactic acid solutions were used and it was found that 0.1 M. solutions had no effect, whereas 0.15 M solutions improved tenderness quality and higher concentration of 0.2 M had no additional advantage. Hence 0.15 M. solutions were used in this study. Further, our earlier studies on evaluation of meat tenderness (Naginchand et al. 1981, Dani et al. 1982) have clearly shown very high correlation (r=0.858) between instrumental values and sensory tenderness scores and the data on instrumental values have been used to predict the tenderness/toughness quality of chicken muscles in this paper as was done earlier for mutton tenderness quality (Mahendrakar et al. 1990). A patent has been filed for a process of improving tenderness quality of chicken meat by using these chemicals (Mahendrakar et al. 2000). The present paper reports the results on the effect of dipping the spent hen muscle cuts in 0.15 M $CaCl_2$, 0.15 M lactic acid and / or their mixture (1:1) on instrumental texture quality.

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Materials and Methods

Twenty-four "White leg horn" layer chickens dressed in the local market (carcass weight 1.0-1.1kg) were brought to the laboratory. The carcasses were washed thoroughly, deskinned and the visible fat was trimmed off. The carcass was vertically split into two halves. The breast and thigh portions were separated from the carcass. Breast and thigh muscle cuts from left carcass were immersed in 0.15 M $CaCl_2$, 0.15 M lactic acid and or their mixtures (1:1) and held at 2-4°C for 65 h. The quantity of chemical solution used was 1 L per kg of muscle cut. The breast and thigh muscle cuts from right half of the carcass were not given any treatment, placed in polyethylene pouches and held at 2-4°C for 65 h (controls). Eight birds were used for each treatment and the following parameters were measured for both treated as well as control samples.

pH : Muscle pH was directly measured by inserting the combined glass-calomel electrode into the incision made into the muscle and by using Toshniwal pH meter.

Moisture content : Muscles dissected out from cuts were minced by cutting into small granules and moisture content was determined by oven method (103°C for 18 h) (AOAC 1995).

Water holding capacity (WHC) : Minced meat was used to determine the WHC by the filter paper press method of Wierbicki and Deathrage (1958).

TABLE 1. GAIN IN WEIGHT OF LAYER CHICKEN MUSCLES DIPPED IN CHEMICAL SOLUTIONS AND LOSS IN WEIGHT OF UNTREATED MUSCLES HELD AT 2-4°C FOR 65 HOURS

Treatment	Breast muscles				Thigh muscles			
	Control		Treated		Control		Treated	
	0 day	3 days	0 day	3 days	0 day	3 days	0 day	3 days
$CaCl_2$	180.6 ± 37.20	173.8 ± 37.08	157.5 ± 41.60	174.4 ± 09.95	157.5 ± 17.32	151.2 ± 17.45	152.5 ± 24.62	166.9 ± 22.40
Lactic acid	150.6 ± 20.68	122.5 ± 15.41	167.5 ± 25.86	207.5 ± 33.81	186.8 ± 16.15	160.6 ± 21.27	150.6 ± 17.57	178.1 ± 21.64
$CaCl_2$+Lactic acid	183.1 ± 31.12	163.8 ± 30.28	120.6 ± 12.34	143.1 ± 21.76	160.6 ± 14.45	145.0 ± 15.61	163.1 ± 21.92	177.5 ± 21.06

Each value is mean ± SD of 8 birds

Firmness : Both breast and thigh muscles were cored using stainless steel corer to obtain 25 mm dia cored samples. The thickness of the cored samples was in the range of 4-8 mm. The cored samples were sheared using Instron Universal Texture Measuring System (Model 4301 UTM) under the following operating conditions :

Plunger : Tooth shaped 25 mm dia plunger

Load cell : 5 Kilo Newton

Bolt torque : 50 Newton meter

Penetration in the sample : 80% of the sample thickness

Firmness (Kg force) was recorded for 3-4 sample cores of each muscle and the mean value calculated for 6 mm thickness is reported.

Statistical analysis : The results were analyzed by the Analysis of Variance Technique using the software SPSS for Windows version 6 (SPSS Inc. 1993).

Results and Discussion

Weight of muscles : When breast and thigh muscles were dipped for 65 h in 0.15 M chemical solutions, the muscle weight increased in all the cases (Table 1). The decrease in the weight was observed in control muscles. Increase in the weight of muscles was 9-11 % with $CaCl_2$ treatment, 18-24 % with lactic acid treatment and 9-19 % when treated with the mixture of the above solutions. On the other hand, decrease in weight in control muscles was in the order of 4-9 % due to drip loss (Table 1). The gain or loss of muscle weight as observed above was expected because of absorption of solutions during soaking of treated and drip loss of untreated muscles respectively.

Moisture content : Moisture content of treated muscles was also higher by 2-5 % compared to control, which was due to absorption of solutions by the muscles as observed above (Table 2). The increase in moisture content in the treated muscles was found to be significant ($P \leq 0.05$) in all the cases.

Water holding capacity (WHC) : WHC of muscles treated with chemical solutions was higher than those of control muscles (Fig.1). The increase in WHC was 12.2, 18.6 and 9.2 % for breast and 9.4, 10.6 and 6.6 % for thigh muscles when treated with $CaCl_2$, lactic acid or their mixtures (1:1) respectively and the treatment effect was statistically significant ($P \leq 0.05$). This observation clearly indicated that the dip treatment of muscles in chemical solutions improved the WHC of muscles.

TABLE 2. MOISTURE CONTENT (G/100G) OF LAYER CHICKEN MUSCLES DIPPED IN CHEMICAL SOLUTIONS (TREATED) AND UNTREATED (CONTROL) MUSCLES HELD AT 2-4°C FOR 65 HOURS

Treatment	Breast muscles		Thigh muscles	
	Control	Treated	Control	Treated
$CaCl_2$	74.2 ± 2.16	76.9 ± 2.20	71.8 ± 4.87	76.7 ± 1.04
Lactic acid	72.7 ± 3.66	77.4 ± 2.78	73.3 ± 3.99	77.6 ± 1.76
$CaCl_2$+Lactic acid	71.7 ± 4.68	73.6 ± 4.06	72.2 ± 4.65	74.6 ± 4.54

Each value is mean ± SD of 8 birds

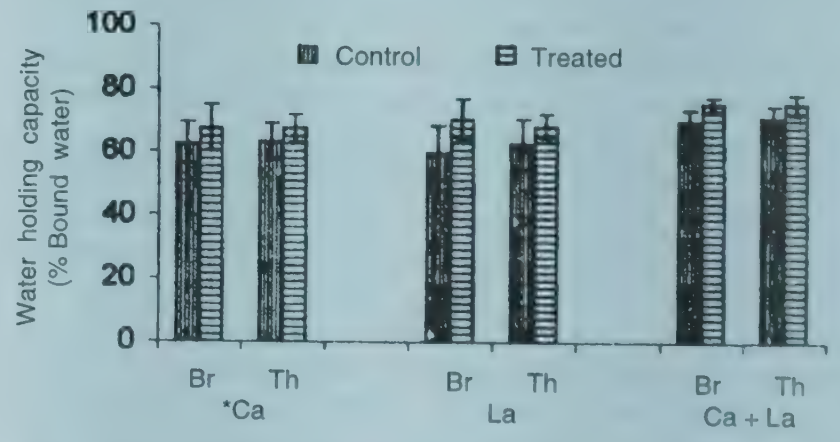

Fig. 1. Water holding capacity of chicken breast (Br) and thigh (Th) muscles
* Treatments : Ca: 0.15 M $CaCl_2$, La: 0.15 M Lactic acid, Ca + La : $CaCl_2$ + Lactic acid (1:1). Each value is the mean of 8 birds. Vertical line indicates standard deviation

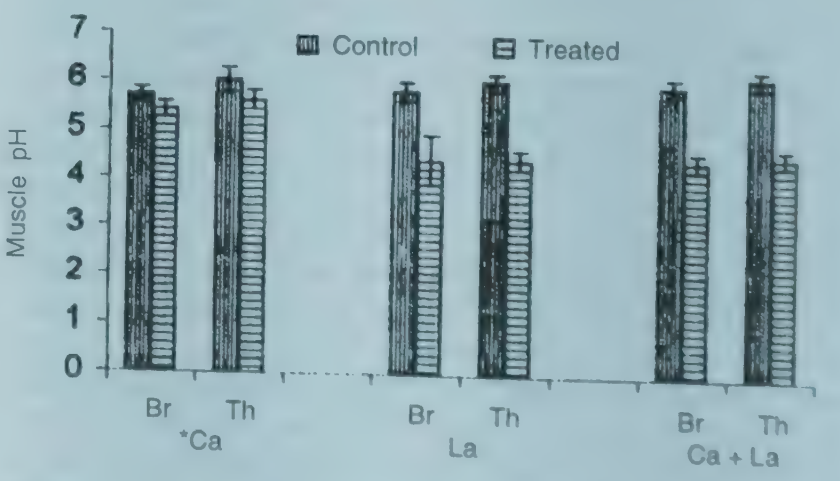

Fig. 2. pH of chicken breast (Br) and thigh (Th) muscles
* Treatments : Ca: 0.15 M $CaCl_2$, La: 0.15 M Lactic acid, Ca + La : $CaCl_2$ + Lactic acid (1:1). Each value is the mean of 8 birds. Vertical line indicates standard deviation

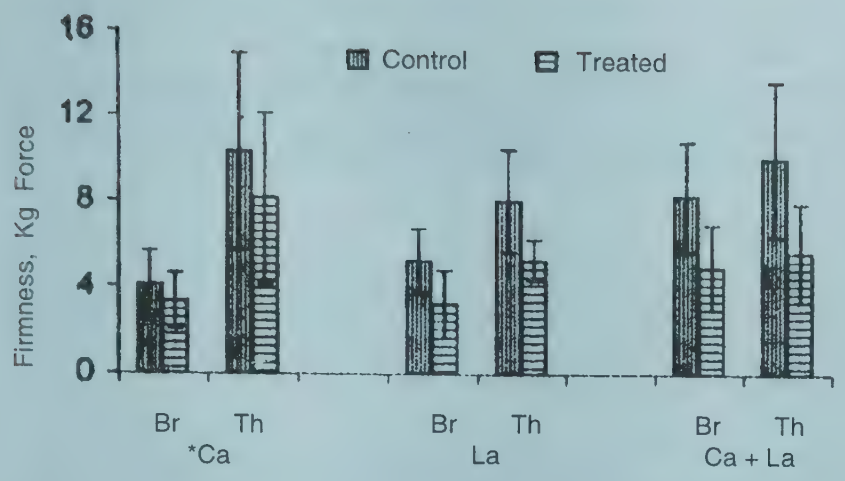

Fig. 3. Texture (Firmness) of chicken breast (Br) and thigh (Th) muscles
*Treatments : Ca : 0.15 M $CaCl_2$, La : 0.15 M Lactic acid, Ca + La : $CaCl_2$ + Lactic acid (1:1). Each value is mean of 8 birds. Vertical bar indicates standard deviation

Mendiratta et al (1996), however, observed reduction in sensory juiciness scores when spent hen muscles were injected with 100-300 mM $CaCl_2$ solution at 10 % (w/w).

pH : pH values of 0.15 M $CaCl_2$, 0.15 M lactic acid and their mixture in equal proportions were 6.8, 2.5 and 2.6, respectively. Muscle pH before treatment was in the range of 5.9-6.1. Treatment with $CaCl_2$ for 65 h slightly brought down the muscle pH to 5.4 -5.7, whereas significant reduction in pH to 4.4-4.5 was noticed in the case of treatments with lactic acid and lactic acid+$CaCl_2$ (1:1) because of the presence of lactic acid (Fig.2). All these differences in pH values of treated and untreated muscles were statistically significant ($P \leq 0.05$ in the case of $CaCl_2$ treatment and $P \leq 0.01$ in the case of treatments with lactic acid and 1:1 lactic acid+$CaCl_2$). These results are in agreement with the earlier observations with $CaCl_2$ treatment for spent hen muscles (Mendiratta et al. 1996), lactic acid treatment for bovine muscles (Stanton and Light 1990) and their combination treatment for mature cow muscles (Eilers et al. 1994).

Firmness : Results of the firmness of control and treated muscles presented in Fig. 3 clearly indicate lower firmness values for all treatments compared to control. Reduction in firmness values in treated muscles compared to untreated counterparts was 20.2, 38.3 and 42.4 % for breast and 21.4, 35.2 and 44.0 % for thigh muscles when treated with 0.15 M $CaCl_2$, 0.15 M lactic acid and their mixture (1:1) respectively. These observations clearly indicate that dip treatment of layer chicken muscles in equal volumes of 0.15 M $CaCl_2$ and 0.15 M lactic acid was more effective in improving the tenderness quality of both breast and thigh muscles compared to the treatment by individual chemical solutions. These results are in agreement with earlier observations on beef muscles when 0.3 M solutions of $CaCl_2$ and lactic acid were injected into the muscles (Eilers et al. 1994).

The tenderizing effect of $CaCl_2$ is explained as due to desirable proteolysis of myofibrillar proteins in or near the z-lines and a calcium dependent solubilization of key myofibrillar proteins (Taylor and Etherington 1991) and that of lactic acid due to degradation of perimysial collagen by the lysosomal enzymes and accelerated conditioning (Stanton and Light 1990, Eilers et al 1994). Besides the native collagen, lactic acid can also degrade myofibrillar proteins, which are responsible for actomyosin toughness (Quali et al. 1987). The increased tenderizing effect of mixture of $CaCl_2$ and lactic acid solutions as observed in the present investigation could be due to desirable proteolytic effect on both myofibrillar and connective tissue proteins.

Conclusions

Chicken muscles absorbed chemical solutions when dipped in 0.15 M $CaCl_2$, 0.15 M lactic acid or their 1:1 mixture for 65 h and stored under chilled temperature (2-4°C), resulting in increased water content and WHC of muscles. Muscle pH was marginally lowered when dipped into 0.15 M $CaCl_2$ solution and significantly lowered when dipped in to 0.15 M lactic acid solution or mixture of both (1:1). The tenderization effect was noticed in both breast and thigh muscles when dipped in 0.15 M $CaCl_2$ or 0.15 M lactic acid or their mixture (1:1), the mixture of solutions being more effective.

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RESEARCH PAPER

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Effect of Storage, Cooking and Chemical Treatment on Protein and Starch Digestibilities of Basmati Rice (*Oryza sativa* L.) Genotypes

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Changes in protein and starch digestibilities were assessed during aging, cooking and chemical treatment of raw and cooked Basmati rice of 12 gentoypes. *In vitro* protein and starch digestibility improved upon storage and after 4, 8 and 12 months. 'Pusa Basmati-1', 'Haryana Basmati-1' and 'Basmati-370' gave higher values for protein and starch digestibility than the other genotypes. Cooked rice showed higher digestibilities of protein and starch than uncooked rice. Among calcium lactate, citrate and disodium phosphate tried, calcium lactate-treated rice gave higher starch and protein digestibility values after all the storage periods. Compared to uncooked chemically treated rice, cooked rice treated with all the chemicals gave higher protein digestibility. The starch digestibility of chemically treated cooked rice was found higher than raw, cooked and chemically treated raw rice. 'Pusa Basmati-1' recorded maximum starch digestibility and 'PR-106' the least.

Keywords : Basmati rice, Protein digestibility, Starch digestibility, Storage, Cooking, Chemical instantization, Rice quality.

Basmati is globally reputed long grain aromatic rice. Its consumers demand is very high specially among people of Indian sub-continent and Middle East countries. Some basmati varieties have very good quality, firmness, aroma and protein contents (Kaul et al. 1982; Dutta et al. 1998). The export of long, slender grain basmati rice commands high premium price in international market. The protein level of rice and its essential amino acid spectrum along with digestibility are extremely important in the context of nutritional value. The alteration in interactions among various chemical constituents are related to changes during cooking, aging and chemical treatments. A wide variation in the digestibilities of starch granule both *in vitro* and *in vivo* is seen, depending upon source of starch, food processing and storage conditions. Rate and extent of starch breakdown in the small intestine have a marked effect on glucose absorption and corresponding insulin response. Starch digestibility is influenced by physical accessibility of starch to digestive enzymes, crystalline pattern of starch in the granule and retrogradation. Recently, glycemic and insulinaemic responses to natural foods, frozen foods and their laboratory equivalents were carried out and possibility of an increase in resistant rice starch served after overnight refrigeration has been explored (Kanan et al. 1998). It is generally believed that aged rice is superior to fresh in terms of nutritional and cooking qualities.

Chemicals believed to act primarilly to modify protein structure by attenuation, disruption and disintegration are citrates of magnesium, calcium and sodium (Gregory 1976). Auxiliary chemicals reported as having beneficial effects are fatty acid glycerides, which prevent adhesion and primary or secondary calcium phosphates, which facilitate absorption of water by the starch and enhance the whiteness of the rice product. An attempt was made in the present investigation to examine the effect of aging, cooking and inorganic salts on protein and starch digestibility of basmati rice genotypes.

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Materials and Methods

Rice samples : Paddy seeds of 'Pusa Basmati-1', 'Haryana Basmati-1', 'Basmati 370', 'Tarori Basmati', 'HKR 91-406', 'HKR 92-301', 'HKR 93-401', HKR 93-402', 'HKR 91-455', 'HKR 92-445', 'HKR - 447', representing Basmati and 'PR-106' a non-basmati type were collected from CCS Haryana Agricultural University, Rice Station, Kaul, India, during December 1996. Paddy samples were dehusked and polished uniformly (8 %) utilising the locally available existing facilities. One kg sample of each genotype was fumigated in an air tight circular steel container of 20 kg capacity with one tablet of aluminium phosphide for 3 days as per the instructions outlined in package of practices (HAU 1981). The rice grains were cleaned off dust, stones, broken seeds and other foreign materials. Rice grains (250 g) of all the genotypes were stored in air tight plastic containers for one year at room temperature and samples were removed after 4,8 and 12 months. Fresh as well as stored rice samples were cooked as per the method described by Singh et al (1977). Ten grams of rice grains were cooked with 20 ml distilled water using 100 ml glass test tubes and heated in a boiling water both till done. The cooking was judged by pressing the kernels between the glass slides at frequent intervals, till no white core left in the kernels. The samples were dried at 60°C to a constant weight.

Chemical treatment of raw and cooked rice : Raw and cooked rice after an interval of each storage period were chemically treated with citric acid (0.2 %), disodium phosphate (0.3 %) and calcium lactate (1.5 %), employing the method of Bhaskar et al (1989) and Lee et al (1995). The representative rice grains were steeped in aqueous solutions of these chemicals separately for 3 h. After draining the solution, the rice samples were dried at 60°C. The raw, cooked, chemically treated raw and cooked rice samples were ground to pass through a 80 mesh sieve and used for estimation of protein and starch digestibilitis. Protein was calculated from nitrogen content determined by the conventional micro Kjeldahl method using a conversion factor of 5.95 (AOAC 1995).

In vitro protein and starch digestibility : *In vitro* protein digestibility was determined by the method of Akeson and Stahman (1964) as modified by Singh and Jambunathan (1981) by using pepsin and pancreatin. Two hundred mg of defatted rice sample was incubated with 5 ml of pepsin (pH2) at 37°C for 16 h, after that pH was adjusted to 7.0 with sodium hydroxide. Two ml of pancreatin solution in borate buffer (pH 6.8) containing calcium chloride was added and again incubated at 37°C for 24 hr. After terminating the reaction with trichloacetic acid, the contents were centrifuged. The nitrogen content of the supernatant was determined and protein digestibility was calculated. Assessment of starch digestibility was made by employing pancreatic alpha amylase as per the method of Singh et al (1982). Defatted rice sample (25 mg) was dispensed in one ml of phosphate buffer (pH 6.9) and incubated with 0.5 ml pancreatic amylase at 37°C for 2 h. The reaction was stopped with dinitrosalicyclic acid and the maltose liberated was monitored at 550 nm.

Results and Discussion

Variations in protein digestibility values were observed in all the fresh, 4, 8 and 12 months stored rice genotypes (Tables 1 to 4). 'Pusa Basmati 1', 'Haryana Basmati 1' and 'Basmati 370' had higher protein digestibilities than the other genotypes listed. The protein digestibility values at 0, 4, 8 and 12 months of storage for 'Pusa Basmati', 'Haryana Basmati' and 'Basmati 370' were 54.86, 56.66, 58.33 and 58.74 % respectively. Sharma and Khetarpaul (1997) reported an average protein digestibility of 56.66 % at maturity that lent support to the present findings. In the present studies, the

TABLE 1. CHANGES IN PER CENT RICE PROTEIN DIGESTIBILITY AS AFFECTED BY COOKING AND CHEMICAL TREATMENTS OF FRESH RICE (MEAN VALUES)

Genotype	Proteins, %	Raw rice	Cooked rice	Before cooking rice treated with			After cooking rice treated with		
				Citrate	Disodium phosphate	Calcium lactate	Citrate	Disodium phosphate	Calcium lactate
'Pusa Basmati-1'	8.28	59.25	69.08	63.92	61.14	60.30	72.17	71.79	74.36
'Haryana Basmati-1'	8.41	56.68	68.06	63.41	59.80	65.10	71.19	70.31	73.29
'Basmati 370'	8.23	56.06	67.96	62.99	60.80	65.11	72.11	71.20	74.27
'PR-106'	7.86	49.05	61.50	52.06	50.79	54.13	62.76	62.07	65.31
'Taraori Basmati'	8.10	55.04	67.75	61.98	60.36	64.21	69.91	69.28	70.94
'HKR 91-406'	8.17	54.19	67.10	61.68	59.79	63.04	71.01	70.07	71.90
'HKR 92-401'	7.90	54.38	66.04	60.36	59.29	61.41	70.85	68.91	71.85
'HKR 93-401'	7.96	55.74	65.11	59.20	58.96	61.23	69.99	68.12	71.41
'HKR 93-402'	7.93	54.74	64.26	59.18	58.11	61.00	69.81	67.83	70.77
'HKR 91-455'	7.95	53.86	65.31	59.61	58.33	61.26	70.02	67.94	70.76
'HKR 92-445'	8.04	55.11	65.21	59.81	58.65	61.44	70.16	68.01	71.91
'HKR 92-447'	8.08	54.26	65.70	59.90	58.16	61.34	70.87	68.36	71.97
Mean	8.08	54.86	66.09	60.34	58.69	62.13	70.07	68.66	71.56
S. Em ±	0.01	0.50	0.57	0.46	0.47	0.44	0.52	0.51	0.48
CD 5 %	0.04	1.53	1.77	1.42	1.45	1.35	1.59	1.58	1.47

Each value is an average of two estimations

TABLE 2. PER CENT PROTEIN DIGESTIBILITY AS INFLUENCED BY COOKING AND CHEMICAL TREATMENTS OF 4 MONTHS STORED RICE (MEAN VALUES)

Genotype	Raw rice	Cooked rice	Before cooking rice treated with			After cooking rice treated with		
			Citrate	Disodium phosphate	Calcium lactate	Citrate	Disodium phosphate	Calcium lactate
'Pusa Basmati-1'	61.02	70.98	65.00	62.78	67.80	74.23	73.28	76.16
'Haryana Basmati-1'	58.04	70.10	65.13	61.76	67.01	73.16	72.31	75.26
'Basmati 370'	57.96	69.89	65.07	62.96	66.98	74.05	73.36	76.16
'PR-106'	51.26	62.75	53.95	52.19	56.06	64.96	64.26	67.25
'Taraori Basmati'	56.13	69.29	63.29	62.12	66.01	71.96	71.15	73.13
'HKR 91-406'	55.95	69.07	63.30	61.15	64.31	72.41	72.11	74.07
'HKR 92-401'	56.31	67.92	62.26	61.01	63.31	72.30	70.43	74.00
'HKR 93-401'	57.96	67.26	61.38	60.91	63.20	71.95	70.13	73.28
'HKR 93-402'	56.27	66.01	61.03	60.21	62.84	71.20	69.36	72.36
'HKR 91-455'	55.81	67.11	61.10	60.35	63.16	71.91	69.85	72.03
'HKR 92-445'	57.05	67.06	61.76	60.56	63.00	72.09	70.00	73.10
'HKR 92-447'	56.16	67.97	61.98	60.46	63.30	72.34	70.29	73.85
Mean	56.66	67.95	62.10	60.54	63.92	71.88	70.54	73.39
S. Em ±	0.44	0.43	0.47	0.39	0.41	0.35	0.34	0.41
CD 5 %	1.37	1.34	1.14	1.21	1.25	1.07	1.05	1.26

Each value is an average of two estimations

TABLE 3. EFFECT OF COOKING AND CHEMICAL TREATMENTS ON PERCENT DIGESTIBILITY OF RICE PROTEIN AFTER 8 MONTHS OF STORAGE (MEAN VALUES)

Genotype	Raw rice	Cooked rice	Before cooking rice treated with			After cooking rice treated with		
			Citrate	Disodium phosphate	Calcium lactate	Citrate	Disodium phosphate	Calcium lactate
'Pusa Basmati-1'	62.33	72.16	66.91	63.96	69.05	75.49	74.92	77.46
'Haryana Basmati-1'	61.01	71.98	67.01	67.01	68.32	78.47	73.69	76.52
'Basmati 370'	60.06	71.49	66.26	64.31	68.38	75.45	74.98	77.54
'PR-106'	53.00	63.60	55.51	54.99	57.47	66.21	65.35	69.00
'Taraori Basmati'	57.53	70.89	64.98	63.33	67.21	73.08	72.31	74.39
'HKR 91-406'	57.51	70.36	65.02	63.06	66.26	73.60	73.20	75.35
'HKR 92-401'	58.06	69.50	64.06	62.91	65.06	74.08	72.11	75.42
'HKR 93-401'	59.68	68.83	62.98	62.16	64.97	73.51	71.46	75.06
'HKR 93-402'	57.79	67.44	62.20	61.29	64.16	73.02	70.98	74.00
'HKR 91-455'	57.15	68.51	63.03	61.96	64.39	73.33	71.32	74.04
'HKR 92-445'	58.36	68.96	63.30	62.11	65.12	73.44	71.95	75.04
'HKR 92-447'	57.53	69.31	63.34	61.99	65.19	73.65	72.05	75.20
Mean	58.33	69.42	63.71	62.02	65.47	73.28	72.03	74.92
S. Em ±	0.36	0.29	0.29	0.31	0.27	0.37	0.34	0.26
CD 5 %	1.55	1.25	1.26	1.33	1.19	1.58	1.46	1.12

Each value is an average of two estimations

TABLE 4. INFLUENCE OF COOKING AND CHEMICAL INSTANTIZATION OF PERCENT RICE PROTEIN DIGESTIBILITY AFTER 12 MONTHS OF STORAGE (MEAN VALUES)

Genotype	Raw rice	Cooked rice	Before cooking rice treated with			After cooking rice treated with		
			Citrate	Disodium phosphate	Calcium lactate	Citrate	Disodium phosphate	Calcium lactate
'Pusa Basmati-1'	63.09	72.93	67.30	64.78	69.96	76.23	75.16	78.08
'Haryana Basmati-1'	60.35	72.38	67.04	63.86	68.91	75.13	74.35	77.29
'Basmati 370'	60.30	72.19	67.10	64.92	69.09	76.07	75.44	78.27
'PR-106'	53.38	65.15	56.07	54.71	57.95	67.06	66.02	69.18
'Taraori Basmati'	58.08	71.38	65.28	64.08	67.75	73.72	73.18	75.07
'HKR 91-406'	58.02	71.21	65.39	63.16	66.71	74.88	74.16	76.04
'HKR 92-401'	58.26	70.23	64.39	63.22	65.39	74.84	73.04	76.19
'HKR 93-401'	59.98	69.40	63.35	63.03	65.25	73.89	71.97	75.40
'HKR 93-402'	58.23	67.90	62.93	62.10	64.78	73.37	71.21	74.23
'HKR 91-455'	57.95	69.09	63.11	62.22	64.95	73.86	72.02	74.40
'HKR 92-445'	59.09	69.38	63.79	62.82	65.44	74.29	72.41	75.93
'HKR 92-447'	58.13	70.01	63.86	62.35	65.93	74.38	72.42	76.05
Mean	58.74	70.10	64.13	62.60	66.00	73.98	72.62	75.15
S. Em ±	0.52	0.42	0.61	0.49	0.47	0.40	0.47	0.44
CD 5 %	1.60	1.31	1.88	1.50	1.44	1.23	1.43	1.36

Each value is an average of two estimations

increase in protein digestibility varied from 0.7 to 6.6 % on storage. Jood and Kapoor (1992) also observed 1.0 to 8.0 % increase in protein digestibility of cereal grains during storage. The improvement in protein digestibility during storage seems to be related to the reduction of phytic acid that is known to inhibit proteolysis (Sharma and Khetarpaul 1995). On the other hand, Jood and Kapoor (1992) opined that the improvement of digestibility may be ascribed to hydrolysis of some native proteins into their corresponding amino acids during storage. Cooking increased the protein digestibility of raw Basmati rice at 0, 4, 8 and 12 months after storage and the corresponding mean values were 66.09, 67.95, 69.42 and 70.10 % (Tables 1 to 4). Som et al (1992) opined that the improvement upon cooking may be due to the inactivation of proteinase inhibitors and opening of protein structure through denaturation. The present observations, demonstrating improved digestibility after cooking, are also in agreement with the results of Hsu et al (1977) and Ravindran (1992). They suggested that heat processing could dissociate the carbohydrate protein interaction thus making proteolysis easier. Data on rice protein also indicated that total protein did not change during storage but the resistance to proteases increased and solubility of protein fractions decreased (Prime et al. 1968; Barber 1972) but the chemical and physico-chemical properties of glutelin changed significantly (Villareal et al. 1976). The protein digestibility data of chemically treated fresh and cooked rice treated with citrate, disodium phosphate and calcium lactate revealed that calcium lactate gave the highest values for protein digestibility. The protein digestibility of chemically treated rice was higher than the raw rice but lower

than the cooked rice but chemically treated cooked rice of the genotypes showed higher values than the corresponding raw rice, cooked rice and chemically treated raw rice (Tables 1 to 4). Abab and El-Tinay (1997) found higher protein digestibility *in vitro* of chemically treated (sodium bisulphite and ascorbic acid) cooked and uncooked sorghum samples than their untreated counterparts. Hamaker et al (1987) observed 1.0 % increase in protein digestibility with 2-mer-captoethanol treated cooked rice over water cooked rice. The possible reason for digestibility improvement of chemically treated rice may be that the chemicals tried might have opened up the protein matrix through the cleavage of the disulfide bonds and thereby increasing accessibility of the digestive enzymes to their substrates.

The average *in vitro* starch digestibility value of raw fresh basmati rice was 48.58 mg maltose released/g whereas 'Pusa Basmati-1', 'Haryana Basmati-1' and 'Basamati-370' had higher starch digestibility than the remaining genotypes (Table 5). The data pertaining to starch digestion at 4, 8 and 12 months of storage depicted in Tables 6 to 8 showed that the digestibility improved and the increase was maximum in 12 months aged rice. Sharma and Khetarpaul (1997) observed an average value of 51.30 (expressed as mg maltose released/g) in rice using pancreatic α-amlylase, which is more or less similar to the present values. Jood and Kapoor (1992) reported increase in starch digestibility of cereal grains during storage and this may be due to hydrolysis of starch into its monomers. From the perusal of data on stored cooked rice starch digestibility, it is quite evident that it increased continuously upto 12 months and an average increase of about 7.9% was noted during this period. Significant difference was noticed between 'PR 106' and the remaining genotypes. The release of maltose

TABLE 5. STARCH DIGESTIBILITY OF FRESH RICE AS AFFECTED BY COOKING AND CHEMICAL TREATMENTS OF 0 MONTH STORED RICE (MEAN VALUES)

Genotype	Raw rice	Cooked rice	Before cooking rice treated with			After cooking rice treated with		
			Citrate	Disodium phosphate	Calcium lactate	Citrate	Disodium phosphate	Calcium lactate
'Pusa Basmati-1'	51.17	62.90	54.40	53.51	55.05	66.00	64.03	66.35
'Haryana Basmati-1'	50.56	62.45	52.55	52.41	53.15	64.14	63.41	64.99
'Basmati 370'	50.13	61.50	53.52	52.96	53.88	62.31	61.42	63.50
'PR-106'	45.95	49.15	47.61	47.08	48.41	51.55	51.17	52.41
'Taraori Basmati'	49.41	61.33	53.07	52.53	53.97	64.26	63.43	66.00
'HKR 91-406'	50.04	59.83	53.37	52.99	53.99	63.07	61.45	63.63
'HKR 92-401'	46.44	59.08	49.17	48.43	50.10	61.47	60.91	62.56
'HKR 93-401'	47.58	60.46	51.59	51.02	52.26	61.90	61.00	62.55
'HKR 93-402'	48.45	60.32	52.43	51.95	53.35	62.43	60.65	63.43
'HKR 91-455'	48.97	60.07	53.09	52.11	54.02	62.45	61.26	64.07
'HKR 92-445'	47.22	60.94	51.12	50.52	51.99	63.47	61.02	63.55
'HKR 92-447'	47.06	59.06	50.52	50.10	51.39	62.04	60.44	63.50
Mean	48.58	59.76	51.87	51.30	52.63	62.09	60.85	63.05
S. Em ±	0.27	0.26	0.31	0.26	0.22	0.24	0.27	0.25
CD 5 %	0.82	0.71	0.94	0.79	0.67	0.75	0.84	0.77

Values are average of two estimations and expressed as mg maltose released/g

TABLE 6. EFFECT OF COOKING AND CHEMICAL TREATMENTS ON STARCH DIGESTIBILITY OF 4 MONTHS STORED RICE (MEAN VALUES)

Genotype	Raw rice	Cooked rice	Before cooking rice treated with			After cooking rice treated with		
			Citrate	Disodium phosphate	Calcium lactate	Citrate	Disodium phosphate	Calcium lactate
'Pusa Basmati-1'	53.03	65.13	56.46	55.68	56.74	67.88	65.79	68.48
'Haryana Basmati-1'	52.92	64.45	54.60	54.50	55.64	66.44	65.43	66.75
'Basmati 370'	52.63	63.47	55.56	54.75	56.59	64.17	63.65	65.47
'PR-106'	47.90	51.32	50.00	48.89	50.44	53.68	53.06	54.56
'Taraori Basmati'	51.49	63.43	55.19	54.56	56.21	66.43	66.55	68.00
'HKR 91-406'	52.38	62.24	55.43	54.77	56.14	64.75	63.46	65.97
'HKR 92-401'	48.89	61.19	51.43	50.49	52.44	63.58	63.03	64.61
'HKR 93-401'	49.98	62.52	53.72	53.76	54.45	63.97	63.08	64.56
'HKR 93-402'	50.53	62.46	54.42	53.70	55.52	64.37	63.02	65.52
'HKR 91-455'	51.26	62.42	55.47	54.38	55.82	64.44	63.39	65.97
'HKR 92-445'	49.30	62.96	53.37	52.68	53.84	65.43	64.61	65.70
'HKR 92-447'	49.62	61.41	52.63	51.94	53.92	63.93	62.00	65.41
Mean	50.83	61.89	54.02	53.34	54.80	64.09	63.01	65.08
S. Em ±	0.25	0.33	0.29	0.42	0.33	0.36	0.46	0.40
CD 5 %	0.78	1.00	0.89	1.29	1.03	1.11	1.43	1.23

Values are average of two estimations and expressed as mg maltose released/g

TABLE 7. INFLUENCE OF COOKING AND CHEMICAL TREATMENTS ON STARCH DIGESTIBILITY OF 8 MONTHS STORED RICE (MEAN VALUES)

Genotype	Raw rice	Cooked rice	Before cooking rice treated with			After cooking rice treated with		
			Citrate	Disodium phosphate	Calcium lactate	Citrate	Disodium phosphate	Calcium lactate
'Pusa Basmati-1'	55.00	67.08	58.26	57.41	58.35	70.08	67.69	70.42
'Haryana Basmati-1'	54.32	66.30	56.48	56.40	57.48	68.34	67.77	68.97
'Basmati 370'	54.27	65.36	57.50	56.96	68.51	66.18	65.32	67.49
'PR-106'	49.39	53.12	31.94	50.88	52.32	55.47	55.05	56.64
'Taraori Basmati'	53.18	65.34	56.82	56.45	58.18	68.33	67.45	68.95
'HKR 91-406'	54.28	64.13	57.24	56.95	58.06	66.91	65.47	67.60
'HKR 92-401'	50.53	63.11	53.11	52.39	54.22	65.45	64.87	66.43
'HKR 93-401'	51.85	64.44	55.50	55.11	56.39	65.53	65.00	66.57
'HKR 93-402'	52.52	64.44	56.32	56.01	57.44	66.33	64.91	67.82
'HKR 91-455'	53.14	64.27	57.19	56.27	58.00	66.33	65.24	67.79
'HKR 92-445'	50.98	64.94	55.23	54.47	56.11	67.36	65.01	67.61
'HKR 92-447'	31.36	63.03	54.52	54.00	54.00	66.13	63.53	67.32
Mean	52.57	63.80	55.84	55.28	56.71	66.04	64.78	66.97
S. Em ±	0.46	0.32	0.37	0.31	0.32	0.31	0.29	0.27
CD 5 %	1.42	1.00	1.14	0.97	0.99	0.95	0.89	0.84

Values are expressed as mg maltose released per gram and average of two determinations

TABLE 8. EFFECT OF COOKING AND CHEMICAL TREATMENTS ON STARCH DIGESTIBILITY OF RICE AFTER 12 MONTHS OF STORAGE (MEAN VALUES)

Genotype	Raw rice	Cooked rice	Before cooking rice treated with			After cooking rice treated with		
			Citrate	Disodium phosphate	Calcium lactate	Citrate	Disodium phosphate	Calcium lactate
'Pusa Basmati-1'	55.53	67.72	59.07	58.22	59.18	70.52	68.56	71.30
'Haryana Basmati-1'	55.36	67.13	57.21	57.18	58.29	68.93	68.15	69.57
'Basmati 370'	55.37	66.26	58.23	57.48	59.32	67.73	65.95	68.28
'PR-106'	50.39	53.76	52.37	51.96	53.05	56.49	55.96	57.35
'Taraori Basmati'	54.17	65.93	58.02	57.60	58.95	69.17	68.28	69.51
'HKR 91-406'	55.07	65.02	58.63	57.48	58.65	67.52	66.18	68.49
'HKR 92-401'	51.38	63.66	53.81	53.37	55.01	66.40	65.48	67.32
'HKR 93-401'	52.46	65.22	56.73	55.51	57.19	66.50	65.53	67.35
'HKR 93-402'	53.42	65.23	57.05	56.51	58.28	67.24	65.44	68.28
'HKR 91-455'	53.99	65.33	57.99	57.11	58.55	67.26	65.73	68.93
'HKR 92-445'	52.35	65.48	56.11	55.27	56.67	68.28	65.63	68.44
'HKR 92-447'	52.15	63.52	55.03	54.59	56.22	66.96	64.45	67.82
Mean	53.47	64.52	56.69	56.02	57.46	66.92	65.45	67.72
S. Em ±	0.27	0.32	0.34	0.32	0.31	0.29	0.33	0.24
CD 5 %	0.83	1.09	1.03	0.99	0.95	0.90	1.02	0.73

Values refer to mg maltose released/g and mean of two estimations

was more upon enzymatic digestion of cooked rice starch compared to uncooked counterparts (Tables 5 to 8). Nural Islam and Mohd Azemi (1998) also observed that gelatinised native starch of 'Mahsuri' cultivar was more susceptible to enzymatic attack by porcine pancreatic α-amylase and amyloglucosidase than ungelatinised native starch. Savitri et al (1987) showed 150 % more sugars in cooked starch compared to uncooked starch but our results showed average increase of 23.01, 21.76, 21.36 and 20.66 % of digested starch at 0, 4, 8 and 12 months storage, when compared to respective raw basmati rice. Similar results were also reported by Mohd Azemi and Wooten (1984) and Hood and Arneson (1976) in maize and tapioca starches. Starch digestibility of chemically treated raw rice was higher than the untreated rice. However, it was lower than the cooked rice. Among the three chemicals used, calcium lactate gave good response followed by citrate and disodium phosphate. The starch digestibility of chemically treated cooked rice was found higher than raw, cooked and chemically treated raw rice. 'Pusa Basmati-1' recorded maximum starch digestibility among the genotypes and 'PR 106' showed significantly lower values than the other genotypes (Tables 5 to 8). Kelkar et al (1996) observed that addition of salt (0.2 M) resulted in 3-12 % increase in rice starch digestibility by pancreatic amylase digestion. Higher digestion products from hydroxypropyl substitued rice starches were also observed on incubation with α-amylase and α-amyloglucosidase (Narul Islam and Mohd Azemi 1998). The possible reasons for higher digestibility of rice starch with

calcium lactate treatment could be due to increased susceptibility of pancreatic alpha amylase to calcium complexed starches or the calcium may have contributed to the retention of pancreatic alpha amylase activity. Moran (1982) observed that pancreatic α-amylase required calcium for its mode of action and it is a metalloenzyme (Stauyffer 1987) that requires calcium ions to form salt bridges between two carbohydrate side chains in order to stabilise the enzyme structure. Hettiarchehy et al (1997) and Kulp and Ponte 2000) suggested that *in vitro* starch digestibility using human salivary amylase can be used to differentiate rice varieties and quality.

It may be concluded that Basmati rice possesses and attains better protein and starch digestibilities during storage and calcium lactate treatment may be useful in further enhancement of digestibility of Basmati rice.

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RESEARCH PAPER

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Effect of Wheat Flour and Extruded Wheat Flour on the Quality of Tortillas and Tortilla Chips

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The effect of replacing instant *masa* flour with wheat flour and extruded wheat flour on the quality of tortillas and tortilla chips was studied. The study revealed that the addition of wheat flour and extruded wheat flour improved the rollability and flexibility scores of tortillas but at higher levels (30 and 40 %) of addition extruded wheat flour gave a sticky *masa* dough. Incorporating fat in the instant *masa* dough also improved the rollability and flexibility scores of tortillas. Coarse instant *masa* flour is more suited for the preparation of tortilla chips and incorporating 10 % wheat flour in the *masa* dough improved the texture of the tortilla chips.

Keywords : Tortillas, Instant *masa* flour, Extruded wheat flour, Tortilla chips.

The process of nixtamalization developed by the ancient Aztec of South America is the alkaline cooking and steeping of corn and is the basis for the production of tortillas and a variety of corn snacks and Mexican foods. In recent years, there has been tremendous growth in the market for Mexican foods throughout the world (Gomez et al. 1989). Nixtamalization begins with cooking whole corn in water containing 1 % lime and steeping overnight. The cooked steeped corn is called nixtamal and is washed with excess water to remove pericarp and residual lime. Instant *masa* flour is finding wide use for the preparation of tortillas, the advantages being ease of use and longer shelf life, while increased cost, lack of flavour and poor product texture are some of the disadvantages (Bedolla et al. 1984). Apart from corn, tortillas are also made from wheat flour. Serna-Saldivar et al (1988) reported that wheat flour tortillas are widely consumed in Mexico and are gaining popularity in the USA.

A number of changes occur in the corn kernel when it is cooked in lime. Gomez et al (1989) reported that nixtamalization caused weakening of cell wall, facilitating the removal of pericarp at the endocarp layer and gelatinization of starch granules. Pflugfelder (1988) reported that the pericarp was the primary component of the 3-9 % corn dry matter losses found in the waste water of commercial alkaline processing plant. During the grinding process the corn is physically torn apart and leads to additional starch gelatinization and granule damage due to the friction produced (Gomez et al. 1989). Bedolla et al (1984) reported that corn with hard endosperm are more desirable in the production of high quality dry *masa* flour. Martinez Flores et al (1998) reported that tortillas from dent corn were of better quality than those from floury corn. Pearled sorghum and soybean have also been used to replace part of the corn in tortillas (Choto et al. 1985, Del Valle et al. 1974, Johnson et al. 1980). Shukla (1997) has reported that 6-12 % shortening is used in the commercial manufacture of tortillas. The advantages of using instant *masa* flour are that the process is simplified, dry *masa* flour has a longer shelf life as compared to fresh *masa* and the dry *masa* can be added to over processed fresh *masa* to adjust its consistency and moistness. Gomez et al (1987) reported that fried corn snacks require a moderately coarse *masa* which is achieved by decreasing the cooking temperature, steeping time and by adjusting stones during grinding. Fried corn snacks made from fine *masa* flour will have bubble or pillow formation on chips, will break easily and occupy too much volume and will have high oil uptake.

The objectives of the present investigation were to study the (i) effect of the addition of wheat flour and extruded wheat flour in instant *masa* flour on the quality of tortillas and tortilla chips, (ii) effect of particle size of instant *masa* flour on the quality of tortilla and tortilla chips, (iii) effect of incorporating fat in *masa* dough on quality of tortillas and tortilla chips.

Materials and Methods

Flint corn (Megha) and bread wheat variety "PBW-343" were procured from Punjab Agricultural University, Ludhiana from 1998 harvest. Hydrogenated oil and refined oil were procured from the local market.

The corn was steeped in 20 lt of water containing 200g of lime (calcium oxide). The corn was cooked for 1 h at 95°C to prepare nixtamal. The cooked corn was allowed to steep in lime water for 20 h. Steep water was drained and the nixtamal was washed with tap water to remove the pericarp. Nixtamalized corn was then ground in an attrition mill into a paste (*masa*). The *masa* was dried in a cabinet drier at 50°C to 12 % moisture content (wb). The dried *masa* was then ground into flour in a hammer mill to form what is called as instant *masa* flour. This was packed in an air tight container till further study.

Particle size distribution of instant *masa* flour was determined by passing instant *masa* flour through standard sieves of different mesh sizes (25, 36, 49, 60, 72,85 and 100). The instant *masa* flour was divided into two fractions, the flour which passed through 60 mesh sieve was termed as fine and the one which was retained was termed as coarse.

Instant *masa* flour (10 g) was dissolved in 100 ml of distilled water and its pH ditermined using a digital pH meter.

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Bulk density of instant *masa* flour was detrmined by weighing 100 ml of instant *masa* flour.

Water absorption index (WAI) and Water solubility index (WSI) of fine and coarse instant *masa* flour as well as wheat flour and extruded wheat flour were determined by the method of Anderson et al (1969). Instant *masa* flour (2 g) was dispersed in 25 ml of distilled water, using a glass rod to break down any lumps. It was allowed to shake in a rotator shaker for 30 min and dispersions were rinsed into tared centrifuge tubes and then centrifuged at 5000 rpm for 10 min. The supernatant was decanted for determination of its solid content and the sediment was weighed. WAI and WSI were calculated by the following expression :

$$WAI = \frac{\text{weight of sediment}}{\text{weight of dry solids}} \quad \ldots\ldots (1)$$

$$WSI\ (\%) = \frac{\text{weight of dissolved solids in supernatant} \times 100}{\text{weight of dry solids}} \quad \ldots\ldots (2)$$

Rheology : Rhelogical properties were measured using Brookfield Viscometer (Brookfield Engineering Inc. model DV-II). Instant *masa* flour (20 g) was dispersed in 200 ml of distilled water and cooked at 100°C for 15 min in a hot water bath. The samples were mixed and brought to 30°C in a TC 500 water bath (Brookfield Engineering Inc. USA). The measurements for shear stress were taken at shear rates of 0.66, 1.32, 2.64, 3.3, 5.28, 6.6, 13.2, 26.4, 66, 132 sec^{-1} two min after spindle number 18 was immersed in the sample. Log-log plots of shear stress v/s shear rate were plotted to determine the consistency index (k) and flow behaviour index (n) using the power law equation (Rao and Rizvi 1986; Ibarz and Pagan 1987).

$$t = k\ (dv/dy)^n \quad \ldots\ldots (3)$$

where t = shear stress (Nm^{-2}), k = consistency index (Nsm^{-2}) and dv/dy= shear rate (s^{-1}).

Tortilla preparation : Instant *masa* flour (200 g) and optimum amount of water at 50°C were mixed in a laboratory mixer (National Manufacturing Co. Lincoln NE, USA) to obtain *masa* dough. The dough was made into balls of 30 g and rested in polyethylene pouches for 20 min. The dough balls were then sheeted by placing them between two plates into flat cakes of 15 cm diameter and 0.2 cm thickness. The flat cake was then baked at 300°C for 1 min in reel type oven (National Manufacturing Co, Lincoln NE), followed by air cooling to 25°C and packing in polyethylene bags, sealing and storing at room temperature (25°C). The percentage shrinkage and per cent moisture loss after baking of tortillas were determined as under:

$$\text{Shrinkage } \% = \frac{\text{change in diameter} \times 100}{\text{initial diameter}} \quad \ldots\ldots (4)$$

Subjective tortilla texture measurement

Rollability : The rollability of tortillas was measured by technique given by Suhendro et al (1998). The tortilla was wrapped and rolled around a 1 cm wooden dowel. Rollability was subjectively recorded by a trained evaluator using a scale of 1 to 5.5 (no cracking, best), 4 (signs of craking but no breaking), 3 (cracking and breaking beginning on surface), 2 (cracking and breaking eminent on both sides) and 1 (unrollable breaks easily).

Flexibility : The tortillas were subjectively evaluated (Suhendro et al. 1998) for overall flexibility i.e. firmness, sqeezability and breakability by a trained evaluator. The overall flexibility score was rated 1-5.5 (extremely soft and flexible, best), 4 (soft and flexible), 3 (slightly firm and rigid), 2 (firm, rigid and flexible) and 1 (extremely firm, rigid and inflexible, worst).

Sensory evaluation of tortilla chips : The sensory evaluation was carried out by a panel of ten judges for colour, flavour and texture using 9 point Hedonic scale with 9 (like extremely) and 1 (dislike extremely).

Preparation of wheat flour : The wheat was cleaned and conditioned to 14% moisture level by adding calculated amount of water and was then milled into flour in a laboratory mill (Brabender Junior Quadrumatic Mill, Germany). Samples were stored in air tight container for further study.

Preparation of extruded wheat flour : The preconditioned wheat was ground in a semolina mill (Brabender) to obtain semolina. The wheat semolina was conditioned to 16 % moisture level by adding calculated amount of water. The semolina was packed in polythylene pouches and kept in refrigerator overnight for moisture equilibration and then extruded in a commercial single screw extruder at 150°C, screw speed of 100 rpm and feed rate of 580 g/min. The extrudates were ground to pass through 30 mesh sieve. The extruded flour was stored in air tight container for further use.

Preparation of wheat flour and extruded wheat flour tortillas : Tortillas were prepared with the addition of wheat flour and extruded wheat flour at levels of 10, 20, 30 and 40%. The % shrinkage and % moisture loss of tortillas after baking was determined. Rollability, flexibility and sensory evaluation of tortillas were carried out as described above.

Preparation of tortilla chips : Tortillas were prepared as mentioned above. The baked flat tortilla was cut into triangular shape and fried in refined oil at 170°C for 45 sec to 1 min. Moisture and oil content of the tortilla chips were determined (Bawa and Singh 1998). Tortilla chips were packed in air tight container for sensory evaluation (colour, texture, flavour, overall acceptability) and were evaluated by a panel of ten judges. Wheat flour and extruded wheat flour were added to the fine and coarse instant *masa* flour at levels of 10% to find out if they affected the sensory scores of the tortilla chips. Effect of fat on the quality of tortilla chips was also evaluated. Fat was added to the *masa* dough during mixing at levels of 0, 5, 10, 15 and 20%.

Results and Discussion

The moisture content of the corn after 20 h of steeping was 51.23 % (wb). The total solids of the steep water at the end of the soaking period was 8.48% respectively, which is due to leaching of corn solids into the steep water. The

TABLE 1. PARTICLE SIZE DISTRIBUTION OF INSTANT *MASA* FLOUR

Mesh size no.	Retention, %*
25	0
36	14.02
44	14.10
60	24.47
72	7.6
85	1.23
100	11.61
through 100	26.97

*Average of three replications

TABLE 2. EFFECT OF ADDITION OF WHEAT FLOUR AND EXTRUDED WHEAT FLOUR ON CONSISTENCY INDEX OF COOKED INSTANT *MASA* SLURRY

Wheat flour, %	Consistency index, Nsm^{-2}*	Flow behaviour index	R^2
0	14.53	0.244	0.985
10	15.28	0.253	0.987
20	16.95	0.281	0.983
30	20.25	0.273	0.979
40	28.98	0.185	0.850
Extruded wheat flour, %	Consistency index, Nsm^{-2}*	Flow behaviour index	R^2
0	14.53	0.244	0.985
10	7.24	0.249	0.993
20	6.37	0.282	0.954
30	3.89	0.299	0.999
40	3.01	0.291	0.997

*Average of three replications

nixtamal obtained was ground into *masa* which was dried in a tray drier to a moisture content of 12 % (wb). The dry *masa* was ground and passed through sieves of different mesh size to determine the particle size distribution (Table 1).

The pH of the instant *masa* flour was 8.55 due to the lime added. The bulk density of the fine and coarse instant *masa* flour was 0.779 and 0.602 g/cm^3 respectively. The WSI and WAI of fine instant *masa* flour were 4.383 % and 3.486 where as that of coarse instant *masa* flour were 3.583% and 3.244, respectively.

The consistency coefficient of cooked slurry of instant *masa* flour was 14.53 Nsm^{-2} (Table 2). With increase in the content of wheat flour in instant *masa* flour by 10, 20, 30 and 40% the consistency coefficient of the cooked slurry increased to 15.28, 16.95, 20.25 and 28.98 Nsm^{-2}, respectively. Whereas the consistency decreased to 7.24,6.37, 3.89 and 3.01 Nsm^{-2}, respectively with increase in extruded wheat flour in instant *masa* flour by 10, 20, 30 and 40% (Table 2). The addition of 40% wheat flour in instant *masa* flour increased the consistency coefficient by 99.37% whereas the addition of 40% extruded wheat flour to instant *masa* flour decreased the consistency by 79.25 %. The decrease in the consistency index of the cooked *masa* slurry could be attributed to the

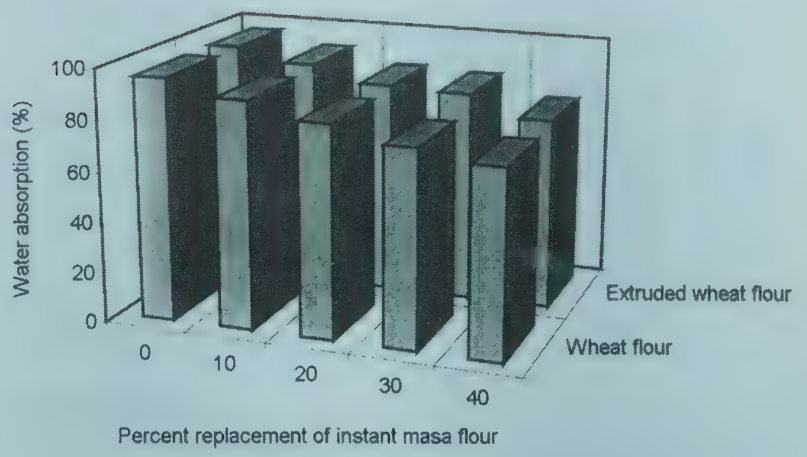

Fig. 1. Effect of addition of wheat flour and extruded wheat flour on the water absorption of instant *masa* dough

TABLE 3. ANALYSIS OF VARIANCE OF ADDITION OF WHEAT FLOUR AND EXTRUDED WHEAT FLOUR IN INSTANT *MASA* FLOUR ON WATER ABSORPTION OF THE *MASA* DOUGH

Source of variation	Sum of squares	Degrees of freedom	Mean sum of squares	F_{tab} value	F_{calcu} value	P value
Replacement	533.4	4	133.35	6.39	48.49	0.001
Extrusion	10	1	10	7.71	3.63	0.129
Error	11	4	2.75			
Total	554.4	9				

ANALYSIS OF VARIANCE OF ADDITION OF WHEAT FLOUR AND EXTRUDED WHEAT FLOUR ON SHRINKAGE OF TORTILLAS AFTER BAKING

Source of variation	Sum of squares	Degrees of freedom	Mean sum of squares	F_{tab} value	F_{calcu} value	P value
Replacement	4.506	4	1.126	6.39	8.954	0.028
Extrusion	1.935	1	1.935	7.71	15.381	0.017
Error	0.503	4	0.125			
Total	6.944	9				

increased gelatinization and solubilization of starch upon extrusion (Singh et al. 1998). The flow behaviour was less than 1 in all the samples (Table 2). This indicates that the cooked slurry was pseudoplastic in nature. The R^2 indicates that the rheological data fitted well with the power law equation.

Water absorption of masa *dough :* The water absorption decreased with increase in wheat flour and extruded wheat flour content but the decrease was higher in case of wheat flour (Fig. 1). The water absorption of the *masa* dough decreased from 96% to 74 % and 76%, when wheat flour and extruded wheat flour were added at 40% level. The decrease in water absorption with increase in wheat flour can be attributed to the decrease in gelatinized starch on addition of wheat flour. Gelatinized starch has higher water absorption (Singh et al. 1998). Addition of extruded wheat flour resulted into a very sticky *masa* dough at levels of 30 and 40%. This can be attributed to increase in solubilized starch and denatured protein in extruded wheat flour. The analysis of variance of data given in Table 3 shows that the effect of replacement was more significant than the effect of extrusion of instant *masa* flour.

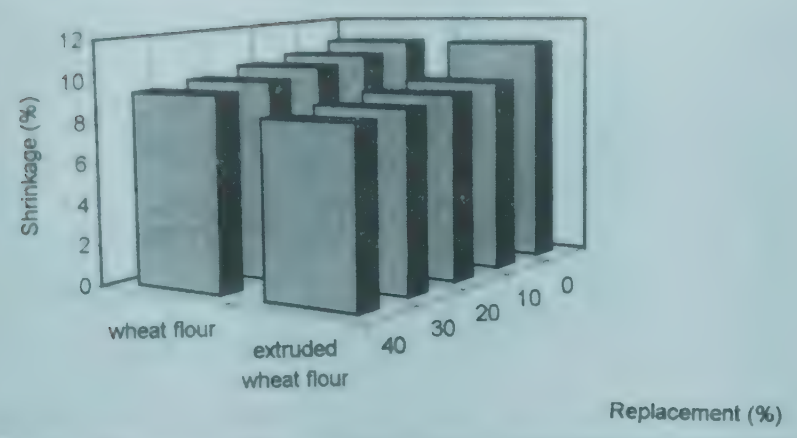

Fig. 2. Effect of addition of wheat flour and extruded wheat flour on shrinkage of tortillas after baking

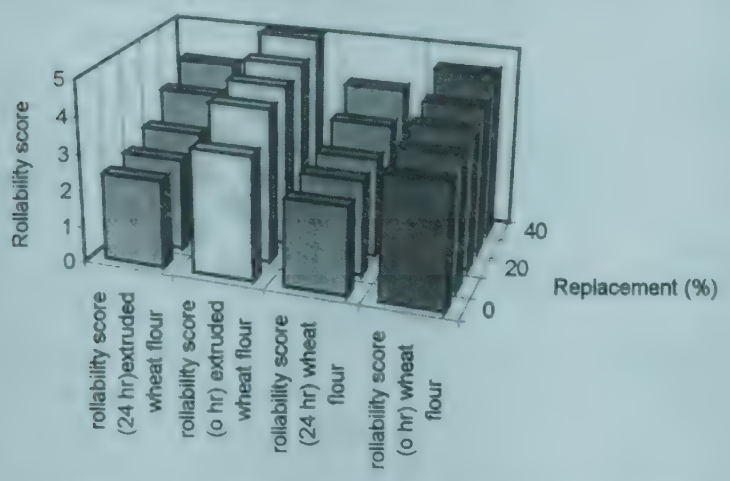

Fig. 3. Effect of addition of wheat flour and extruded wheat flour on the rollability scores of tortillas after 0 and 24 h of storage

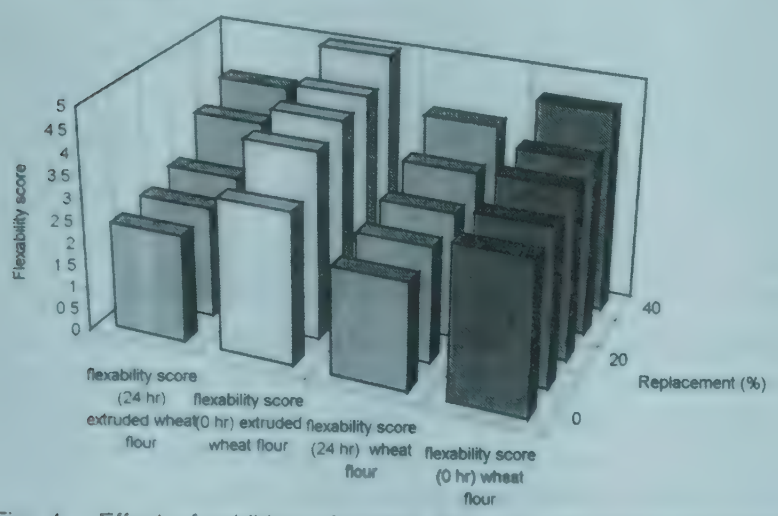

Fig. 4. Effect of addition of wheat flour and extruded wheat flour on the flexibility scores of tortillas after 0 and 24 h

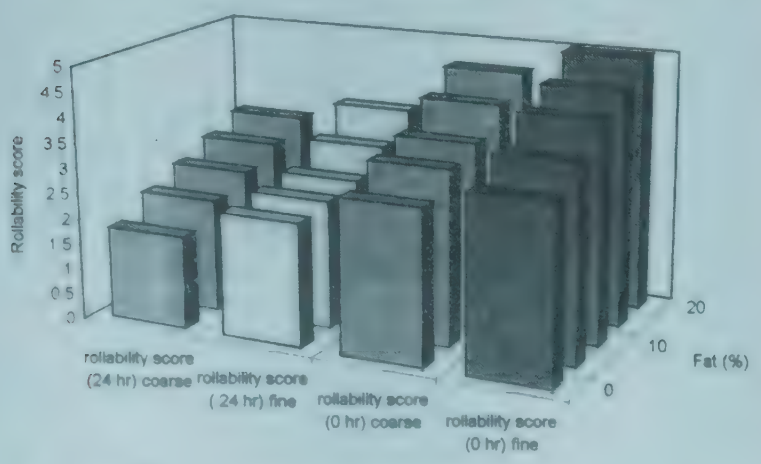

Fig. 5 Effect of fat content on rollability scores of tortillas made from fine and coarse *masa* flour after 0 and 24 h of storage

Shrinkage in tortillas after baking : Addition of wheat flour and extruded wheat flour instant *masa* flour lead to a decrease in the shrinkage, the decrease being lower in extruded wheat flour (Fig. 2). There was 10.88% shrinkage in tortillas made from 100% instant *masa* flour but shrinkage was lowered to 9.43 and 8.45% when wheat flour and extruded wheat flour were added at levels of 40% in instant *masa* flour. The analysis of variance of data in Fig. 2 is given in Table 3 and shows that the effect of extrusion was more significant than the effect of replacement.

Effect of wheat flour and extruded wheat flour addition on rollability and flexibility scores : Addition of wheat flour increased the rollability scores which could be attributed to the gluten provided by the wheat flour in *masa* dough. The rollability scores decreased after 24 h of storage but the decrease was less in tortillas which contain higher levels of wheat flour (Fig. 3). Analysis of variance of data in Fig. 3 revealed that effect of storage time on the rollability scores was more significant than the increase in wheat flour content. With increase in the wheat flour content rollability score was significantly effected at 1% level of significance. Rollability scores after 24 h were significantly affected at 1% level of significance. Similarly flexibility improved with addition of wheat flour in the instant *masa* flour but the scores decreased after 24 h of storage (Fig. 4).

Addition of extruded wheat flour improved the rollability scores (Fig. 3). At 40 % level extruded wheat flour showed higher rollability score as compared to wheat flour. The rollability scores decreased after 24 h of storage but decrease was less in tortillas containing higher levels of extruded wheat flour (Fig. 3). Increasing the extruded wheat flour content significantly effected the rollability score at 5% level of significance. After storage for 24 h there was significant difference between the rollability score at 1% level of significance. The flexibility scores also improved with the addition of extruded wheat flour (Fig. 4).

Effect of fat content on rollability and flexibility scores : Increasing fat content in the *masa* dough increased the rollability and flexibility scores (Fig. 5 and 6). The rollability and flexibility scores of tortillas containing fine instant *masa* flour was higher than those containing coarse instant *masa* flour. Increasing fat content significantly affected the rollability score of tortillas at 0.1% level. Rollability score of tortillas made from fine and coarse *masa* flour with added fat content were significantly different from each other at 0.1% level of significance. Storage lead to a decrease in the rollability and flexibility scores. The decrease was more in tortillas containing less fat and the tortillas made from coarse instant *masa* flour had lower rollability score after 24 h of storage as compared to tortillas made from fine instant *masa* flour at the same level of fat addition. Fat significantly effected the rollability score of tortillas made from fine and coarse *masa* flour at 5% level of significance after 24 h of storage.

Tortilla chips : Tortillas containing higher levels of fat required lower frying time as compared to fat free tortillas. The average oil content of tortillas was 20.7%. The results in Fig. 7 revealed that all the sensory attributes of tortilla chips

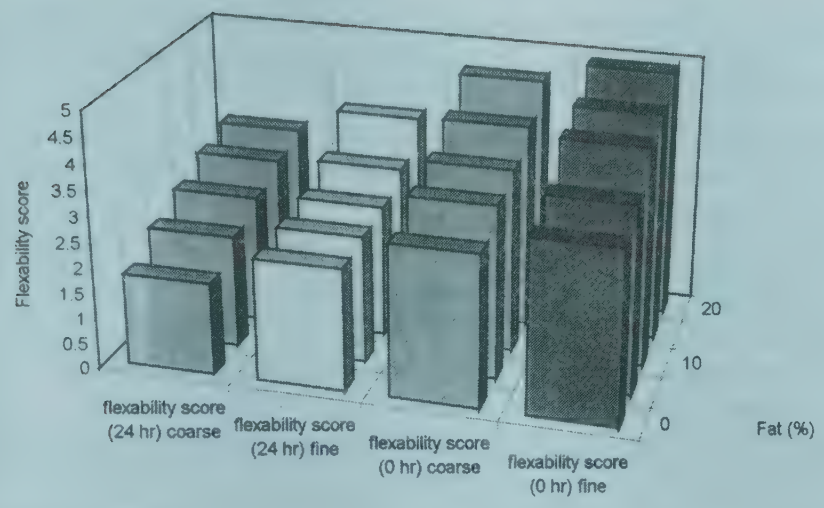

Fig. 6. Effect of fat content on the flexibility scores of tortillas made from fine and coarse *masa* flour after 0 and 24 h of storage

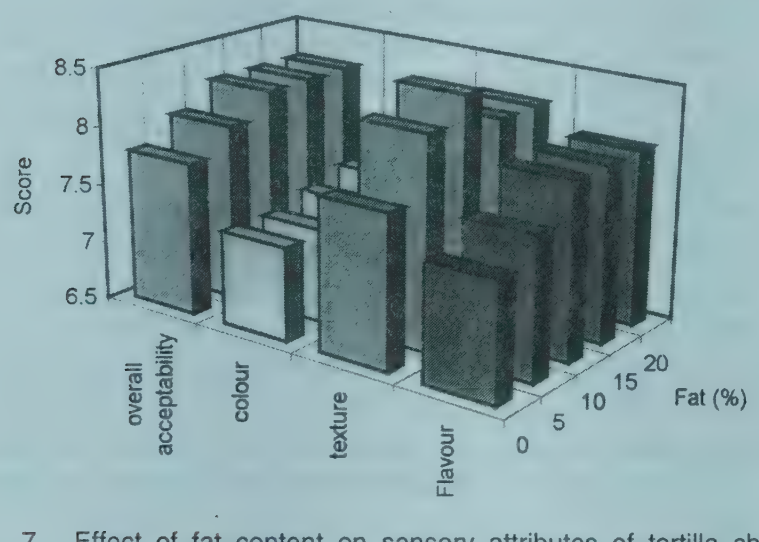

Fig. 7. Effect of fat content on sensory attributes of tortilla chips

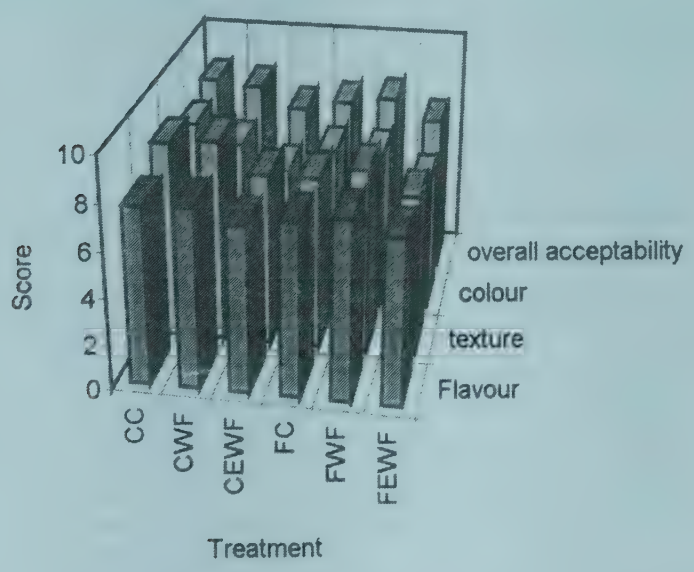

Fig. 8. Effect of wheat flour and extruded wheat flour on sensory attributes of tortilla chips

were significantly affected with increase in fat content of *masa* dough. The tortilla chips made from dough containing 10% fat received the highest scores. Similar results have been reported for Matar (Bawa and Singh 1998). The texture of tortilla chips improved with increase in fat content but at levels of 15-20% the texture became very fragile and the tortillas tended to break in package. Therefore tortillas with 10% fat have been considered best. Table 4 shows the differences among the

TABLE 4. MEAN SUM OF SQUARES FROM ANALYSIS OF VARIANCE OF THE SENSORY SCORES OF TORTILLA CHIPS AT DIFFERENT PER CENT FAT

Source of variation	Degrees of freedom	Flavour	Colour	Texture	Overall acceptability
Fat (%)	4	0.53**	0.1*	0.65*	0.32*
Panel	9	0.208*	0.83**	0.24*	0.236*
Error	36	0.141	0.111	0.268	0.141

*not significant at 5 % level, **significant at 5 % level

TABLE 5. COMPARISON BETWEEN TORTILLA CHIPS MADE FROM FINE INSTANT *MASA* FLOUR CONTAINING 0 AND 10 % FAT USING T TEST

Fat (%)	Flavour	Colour	Texture	Overall acceptability
CC/10C	2.06*	0.845*	0.43***	0.79*
FC/10F	0.00	1.11*	0.000	0.381
10C/10F	2.033	4.33***	3.03**	3.32***
CC/FC	1.209	5.926****	3.618***	3.29***

*not significant at 5%, ** significant at 5%, ***significant at 1%, ****significant at 0.1%

CC is coarse instant *masa* flour (0% fat)

10C is coarse instant *masa* flour (10% fat)

FC is fine instant *masa* flour (0% fat)

10 FC is fine instant *masa* flour (10% fat)

TABLE 6. MEAN SUM OF SQUARES

Source of variation	Degrees of freedom	Flavour	Colour	Texture	Overall acceptability
Treatment	5	0.786**	4.8***	4.53***	2.66***
Judges	9	0.255*	0.32*	0.35**	0.189*
Error	45	0.214	0.193	0.156	0.138

*not significant at 5 %, **significant at 5 %, ***significant at 1%

sensory characteristics and panel for the tortilla chips made from *masa* dough containing different levels of fat.

T-test was used to compare sensory attributes of tortilla chips made from coarse instant *masa* flour with 0 and 10% fat (Table 5). The increase in fat did not significantly affect the texture, flavour and overall acceptability at 5% level of significance but affected the colour at 1% level of significance.

Wheat flour and extruded wheat flour were added to the coarse and fine instant *masa* flour at 10% level to make tortilla chips. The sensory characteristics were evaluated using nine point Hedonic scale (Fig. 8) and the analysis of variance is given in Table 6. Addition of 10% wheat flour in the coarse and fine instant *masa* flour produced the best tortilla chips with respect to flavour. The various treatments significantly affected the flavour at 5% level of significance.

Wheat flour (10%) in coarse instant *masa* flour produced tortillas with best texture. Texture was significantly affected at 1% level of significance due to the various treatments. Tortilla chips made from 100% coarse instant *masa* flour resulted in tortilla chips with the best colour. This may be due to higher levels of soluble sugars in extruded wheat flour which lead to

more browning during the frying process. The tortilla chips made from 100% coarse instant *masa* flour received the highest score for overall acceptability and those made from fine instant *masa* flour containing 10% extruded wheat flour were the least acceptable.

Conclusion

The study revealed that incorporation of wheat flour and extruded wheat flour in instant *masa* flour improves the rollability and flexibility score of tortillas. The tortillas containing extruded wheat flour received higher scores for rollability and flexibility after 24 h of storage. However addition of extruded wheat flour at high levels (30 and 40%) results in a sticky dough and the resulting tortillas did not have the flavour and colour of tortillas made from 100% instant *masa* flour. Incorporation of fat in *masa* dough improves the rollability scores of tortillas and the scores were higher even after 24 h of storage. Tortilla chips made from coarse instant *masa* flour and containing 10% fat received the highest score for flavour, texture, colour and overall acceptability. Chips containing wheat flour were more acceptable as compared to chips containing extruded wheat flour.

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RESEARCH PAPER

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Dehulling Responses of Rapeseed as Influenced by Grain and Machine Parameters

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A study was carried out to determine the dehulling behaviour of rapeseed with respect to grain and machine parameters so as to establish the optimum level of parameters for maximum recovery. Four levels of moisture content (4.2, 6.4, 8.7, 11.1% d.b.), two seed sizes (large and small), 3 peripheral speeds (10, 9, 8 m/s) and 3 levels of clearance (0.5, 0.6, 0.7 mm for large and 0.3, 0.4, 0.5 mm for small size seeds) were selected for the study. The maximum dehulled fraction recoveries (59.21 and 52.73%) and dehulling efficiencies (68.15 and 61.27%) were obtained at 6.4-8.7% (d.b.) moisture content, 8 m/s roller speed, 0.5 mm clearance for large size seeds and 0.3 mm clearance for small size seeds respectively. The second order mathematical model best described the dehulling responses. Moisture content was found to be the most significant parameter to influence these responses.

Keywords : Dehulling, Dehusking, Rapeseed, Mustard, Canola, Pre-treatment, Grain parameter, Machine parameters.

Rapeseed-mustard that contains about 40-45% oil and 20-25% protein is one of the most important oilseed crops in India. The rapeseed meal obtained after oil extraction is considered as an excellent and rich source of protein. The deoiled rapeseed meal could be utilized for direct consumption in various forms like protein concentrate, isolate or as a fortifying agent in many food formulations. However, its use in human diet is restricted by the presence of some toxic and undesirable elements such as glucosinolate, crude fibre and bitter factors (Maheshwari et al. 1981; Niewiadomski 1990; Schwaiger 1997).

For effective and efficient utilization of rapeseed meal in human diet, a number of appropriate processing technologies are adopted. Dehulling of rapeseed before oil extraction is one such technology that can improve meal and oil quality and make the resultant product suitable for human consumption (Anjou 1992; Ohlson 1992; Carr 1995). Dehulling process depends on the grain (i.e. grain size and moisture content) and machine (i.e. peripheral speed of rolls, clearance between the rolls, feed rate etc.) parameters. Only, limited work has been done regarding the effect of grain (Sokhansanj et al. 1992; Laskowski et al. 1996) and machine parameters (Jones et al. 1978, Schneider 1982) on dehulling of rapeseed. Therefore, a detailed study on the dehulling behaviour of rapeseed as influenced by grain and machine parameters was undertaken to establish the optimum level of parameters required for best dehulling and the mathematical models to describe the dehulling process.

Materials and Methods

Investigations on dehulling responses were conducted on rapeseed (variety 'PT-303'). The initial characteristics of the rapeseed sample were 7.72% (d.b.) moisture content, 1.0-2.4 mm particle size distribution, 17.33% hull content, 41.22% oil content, 694.44 kg/m^3 bulk density and 0.92 spherecity. The experiments were conducted at four levels of moisture content i.e. 4.2, 6.4, 8.7 and 11.1% (d.b.) two seed sizes large (> 1.4 mm) and small (< 1.4 mm), three levels of peripheral speed (i.e. 10, 9 and 8 m/s) and 3 levels of clearance between the rubber rolls for each seed size i.e. 0.5, 0.6, 0.7 mm for large size seeds and 0.3, 0.4, 0.5 mm for small size seeds. The clearance was adjusted with the help of filler gauges. The steps followed in the study are illustrated in Fig. 1 and are briefly discussed below.

Cleaning and grading : Cleaning and grading of rapeseed was done on dockage tester. During the process, impurities like trash, chaff, sticks were removed and subsequently the seeds were graded by passing through two sieves (sieve numbers 20 and 7). The seeds that passed through sieve no. 20 but retained over sieve no. 7 (size > 1.4 mm) were considered as large size seeds. Similarly, seeds that passed through sieve no. 7 but retained over sieve no. 1 (size < 1.4 mm) were considered as small size seeds.

Conditioning : The rapeseed samples were conditioned to 8.7, 11.1 and 13.6% (d.b) moisture contents to attain sample moisture contents of 6.4, 8.7 and 11.1% (d.b) respectively because during subsequent preheating step these samples lost approximately more than 2 percentage points of moisture. Conditioning was done by adding calculated amount of water to the samples filled in airtight bottles of one liter capacity. The bottles were placed into a hand operated tumbling mixer and mixed slowly for 30 min. For equilibration of moisture, samples after mixing were kept for 24 h (Smith et al. 1993). During this period intermittent mixing of the samples was done. The moisture content of 4.2% (d.b.) was obtained by oven drying the samples at a temperature of 90 ± 1°C.

Pre-heating : The high oil content (40%) of the seeds causes the meat to adhere to the hulls which hinders the dehulling process. Therefore, samples were preheated at 95°C for 15 min. This facilitates the process of dehulling (Hutchins 1968).

Dehulling : Dehulling of the samples was carried out in a Satake rice dehusker. The desired speed and clearance between the rolls were set before conducting experiments. Peripheral speeds of 10, 9 and 8 m/s were obtained by

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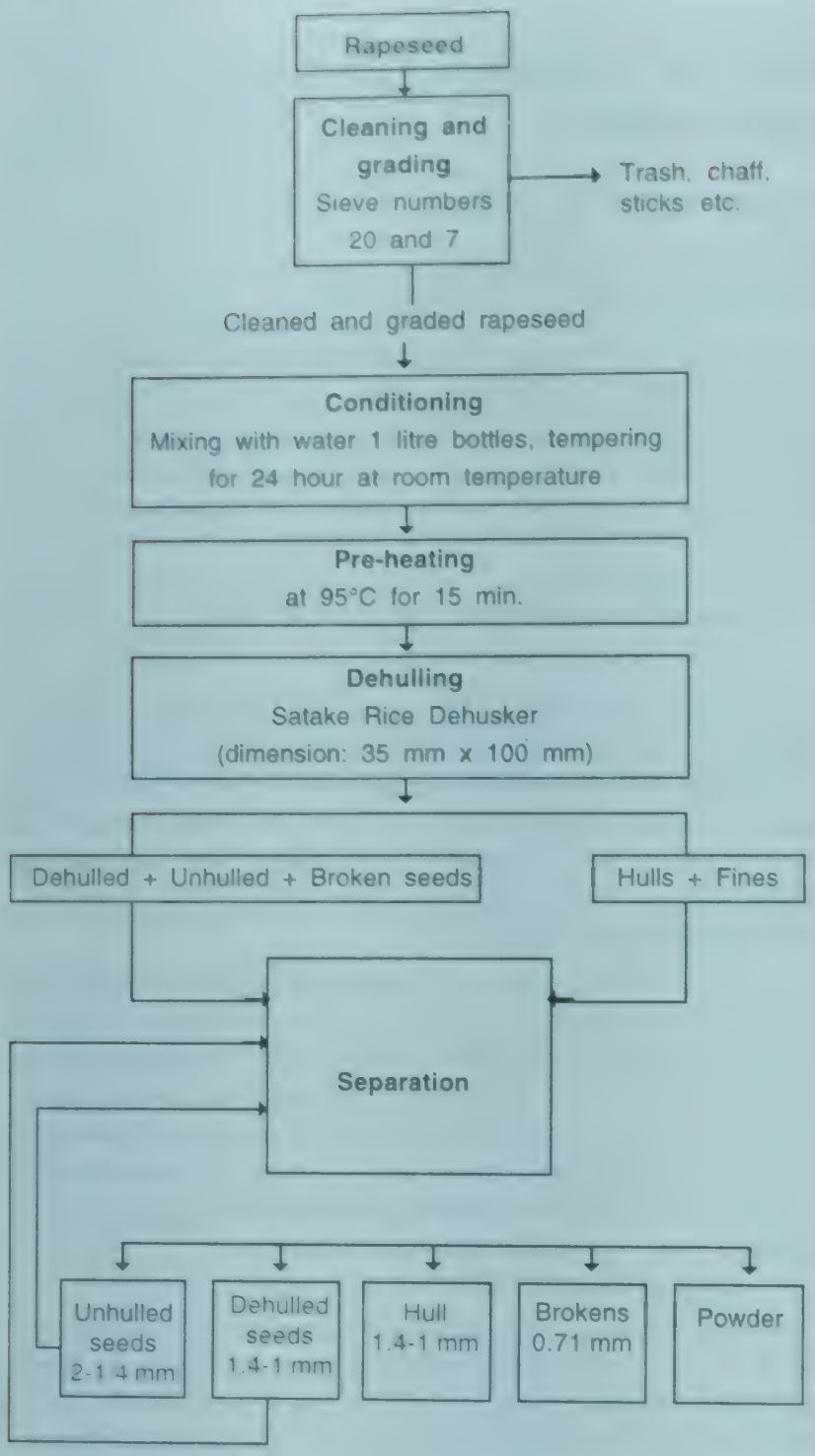

Fig. 1. Flow chart of the dehulling process

adjusting the rpm of the second roll to approximately 2000, 1800 and 1600, respectively. The clearances of 0.3, 0.4, 0.5, 0.6 and 0.7 mm were set with the help of filler gauge and the side screw provided on the machine. Samples weighing 200 g each were fed through the hopper and allowed to pass between the rubber rolls at the specified clearances. This caused the seeds to split between the rubber rolls. The products of dehulling process were collected in the receptacles at the bottom of the dehusker. The dehulled products consisted of mainly two fractions i.e.(i) dehulled and unhulled whole seeds and dehulled broken seeds and (ii) hulls and fines including powder.

Separation : The dehulled products were separated into unhulled seeds, dehulled seeds, brokens, powder and hulls by sieving process using sieve sizes of 2 mm, 1.4 mm, 1 mm, 0.71 mm and less than 0.71 mm. The seeds retained over 2 mm sieve were the unhulled seeds. The fractions retained over 1.4 mm and 1 mm sieves consisted of dehulled seeds. Brokens were collected over 0.71 mm sieve and powder passed through 0.71 mm sieve. The unhulled fraction, which contained some parts of dehulled seeds, was further separated manually. Wherever required, manual separation of other fractions was also carried out. Hulling efficiency was calculated using the formula suggested by Saxena (1985) for pigeonpea, given as below :

$$\text{Hulling efficiency, \%} = \left(1 - \frac{W_{uh}}{W_t}\right)\left(\frac{W_d}{W_d + W_{br} + W_p}\right) \times 100$$

where,

W_{uh} = unhulled seed weight, g; W_t = total sample weight, g; W_d = weight of dehulled seed, g; W_{br} = weight of brokens, g; W_p = weight of powder, g

Results and Discussion

The dehulling responses measured as percentage of dehulled, unhulled, hull, brokens, powder and also the dehulling efficiency for the two seed sizes are presented in Tables 1 and 2. An analysis of these responses in relation to grain and machine parameters and discussion thereon is as follows.

Effect of grain and machine parameters on dehulling responses of large size seeds : The fraction of dehulled product varied from 23.67 to 59.21 %. However, most of the values at 6.4 and 8.7 % (d.b.) moisture content and 8 m/s speed are well within the range (50-75 %) obtained by other research workers (Stanley and Deman 1974; Jones et al. 1978). The maximum dehulled product (59.21 %) was obtained at 6.4 % moisture content, 8 m/s speed and 0.5 mm clearance, while the minimum (23.67 %) was at 11.1 % moisture content, 10 m/s speed and 0.7 mm clearance. The percentage of unhulled seeds was minimum (0.56 %) at 4.2 % moisture content, 9 m/s speed and 0.6 mm clearance and maximum (56.74 %) at 11.1 % moisture content, 10 m/s speed and 0.7 mm clearance.

The broken fraction varied from 1.23 to 14.10 %. The minimum value was obtained at 11.1 % moisture content, 8 m/s speed and 0.7 mm clearance while the maximum was at 4.2 % moisture content, 8 m/s speed and 0.6 mm clearance. Similarly, the powder fraction varied from 0.75 to 31.64 % with minimum being at 11.1 % moisture content, 8 m/s speed, 0.7 mm clearance and maximum at 4.2 % moisture content, 10 m/s speed and 0.6 mm clearance.

Hull percentage, which is an indirect indicator of the extent of dehulling, was maximum (19.01 %) at 8.7 % moisture content, 8 m/s speed and 0.6 mm clearance and minimum (5.80 %) at 11.1 % moisture content, 8 m/s speed and 0.6 mm clearance. However, the values of hull obtained at 6.4 % moisture content were close to those at 8.7 % moisture content but were much higher than those obtained at 4.2 and 11.1 % moisture.

From Table 1, it is evident that maximum value of dehulling efficiency (68.15 %) corresponds to the experimental conditions of 6.4 % moisture content, 8 m/s speed and 0.5 mm

TABLE 1. EFFECT OF GRAIN AND MACHINE PARAMETERS ON DEHULLING FRACTIONS OF LARGE SIZE SEEDS

Moisture content, % (w.b.)	Speed, m/s	Clearance, mm	Dehulled fraction, %	Unhulled fraction, %	Hull fraction, %	BroKen fraction, %	Powder fraction, %	Dehulling efficiency, %
4.2	10	0.5	41.46	2.21	13.02	12.21	31.10	47.83
4.2	10	0.6	45.52	1.67	9.60	11.56	31.64	50.45
4.2	10	0.7	49.48	2.25	11.71	7.93	28.64	56.21
4.2	9	0.5	42.59	1.15	12.56	13.93	29.77	48.79
4.2	9	0.6	46.99	0.56	13.05	12.46	26.94	54.09
4.2	9	0.7	50.91	5.27	14.34	10.01	19.46	60.00
4.2	8	0.5	48.12	0.58	11.94	11.89	27.46	54.69
4.2	8	0.6	49.34	0.96	14.43	14.16	21.11	57.75
4.2	8	0.7	54.65	1.65	15.97	9.72	18.02	65.24
6.4	10	0.5	47.78	11.16	13.07	9.01	18.98	56.02
6.4	10	0.6	43.58	11.95	15.21	12.64	16.62	52.68
6.4	10	0.7	37.26	38.09	12.03	6.06	6.56	46.24
6.4	9	0.5	55.15	9.58	10.65	11.66	12.96	62.52
6.4	9	0.6	46.76	28.07	13.46	5.61	6.10	57.52
6.4	9	0.7	43.10	32.70	11.20	7.35	5.66	51.70
6.4	8	0.5	59.21	8.34	12.03	10.08	10.34	68.15
6.4	8	0.6	54.06	22.81	12.47	5.40	5.26	64.48
6.4	8	0.7	49.99	27.09	15.81	3.57	3.54	63.83
8.7	10	0.5	48.71	27.26	10.32	7.46	6.25	56.76
8.7	10	0.6	47.94	30.75	8.46	5.77	7.08	54.62
8.7	10	0.7	44.05	39.02	8.09	4.28	4.56	50.78
8.7	9	0.5	50.14	19.22	15.77	10.51	4.35	62.31
8.7	9	0.6	48.93	25.93	18.56	3.91	2.68	65.29
8.7	9	0.7	45.71	39.63	8.61	2.98	3.07	53.32
8.7	8	0.5	50.41	18.02	16.07	9.89	5.61	62.70
8.7	8	0.6	50.04	23.40	19.01	4.71	2.83	66.56
8.7	8	0.7	45.05	36.85	9.89	4.79	3.42	53.42
11.1	10	0.5	33.45	47.52	11.43	4.52	3.08	42.77
11.1	10	0.6	27.19	50.39	13.05	5.55	3.82	36.89
11.1	10	0.7	23.67	56.74	11.77	3.69	4.12	32.53
11.1	9	0.5	36.65	45.08	7.58	5.04	5.64	42.52
11.1	9	0.6	31.38	48.37	10.33	6.00	3.92	39.22
11.1	9	0.7	30.28	52.69	9.83	2.25	4.95	38.23
11.1	8	0.5	45.06	30.75	12.41	4.83	6.95	54.90
11.1	8	0.6	39.35	49.32	5.80	2.80	2.73	44.43
11.1	8	0.7	37.12	52.96	7.95	1.23	0.75	44.67

clearance. The minimum value of 32.53 % pertained to 11.1 % moisture content, 10 m/s speed and 0.7 mm clearance. These results are in agreement with those reported by Sarkar et al. (1995).

It is well known that the magnitude of compressive forces in the hulling zone in twin rubber roll dehusker depends on the difference in the speed of the two rolls and clearance between the rolls. The peripheral speed controls the residence time of the grain in the dehulling zone. The deformation characteristics of the grain in the dehulling zone largely depend on the moisture content of the grain. It is because of these facts that the dehulled product obtained was minimum at 11.1 % moisture content as the grains, at this moisture content, may have behaved more like an elastic material and most grain may have passed through the dehulling zone unhulled. This may have also resulted in minimum breakage and powder at this condition. Consequently, the dehulling efficiency was also low.

The grains at 4.2 % moisture content may have behaved like a brittle material and therefore resulted in maximum breakage and powder. This also lowered the dehuling efficiency. The above shows that the suitable moisture content range for dehulling of rapeseed is 6.4 to 8.7 % (d.b.) when the grain is neither too elastic nor too brittle.

Table 1 further reveals that, except at 4.2 % moisture content, dehulled fraction decreased with increase in clearance.

TABLE 2. EFFECT OF GRAIN AND MACHINE PARAMETERS ON DEHULLING FRACTIONS OF SMALL SIZE SEEDS

Moistire content, % (w.b.)	Speed, m/s	Clearance, mm	Dehulled fraction, %	Unhulled fraction, %	Hull fraction, %	BroKen fraction, %	Powder fraction, %	Dehulling efficiency, %
4.2	10	0.3	25.16	1.18	13.68	17.20	42.78	29.20
4.2	10	0.4	33.80	0.28	10.73	13.00	42.19	37.88
4.2	10	0.5	34.00	0.27	10.21	13.42	42.09	37.88
4.2	9	0.3	26.88	0.70	5.85	11.74	54.83	28.57
4.2	9	0.4	31.78	0.51	17.06	16.76	33.88	38.36
4.2	9	0.5	32.88	1.75	10.85	11.71	42.82	36.96
4.2	8	0.3	12.26	0.21	7.06	13.11	67.36	13.19
4.2	8	0.4	30.87	0.24	7.52	13.23	48.14	33.39
4.2	8	0.5	37.68	0.24	7.57	10.88	43.63	40.77
6.4	10	0.3	42.71	2.94	14.81	8.31	31.23	50.39
6.4	10	0.4	41.95	3.19	13.97	10.74	30.15	49.02
6.4	10	0.5	39.97	4.93	12.53	16.41	26.17	46.03
6.4	9	0.3	47.82	12.87	14.26	8.16	16.89	57.18
6.4	9	0.4	41.92	25.76	13.06	9.00	10.26	50.87
6.4	9	0.5	41.92	23.84	14.15	7.11	12.97	51.48
6.4	8	0.3	52.73	10.25	12.51	8.88	15.63	61.27
6.4	8	0.4	49.45	17.18	10.78	6.17	16.42	56.85
6.4	8	0.5	47.63	32.82	8.46	4.27	6.82	54.49
8.7	10	0.3	45.38	15.38	13.79	19.43	6.02	54.21
8.7	10	0.4	43.65	26.68	10.72	13.90	5.06	51.12
8.7	10	0.5	42.23	30.54	10.47	11.56	5.21	49.72
8.7	9	0.3	47.43	16.39	12.18	15.60	8.40	55.52
8.7	9	0.4	44.14	17.98	13.38	12.83	11.67	52.75
8.7	9	0.5	43.66	32.89	14.51	4.62	4.32	55.70
8.7	8	0.3	49.13	18.18	10.99	11.84	9.87	56.75
8.7	8	0.4	44.82	33.61	11.90	4.40	5.27	54.60
8.7	8	0.5	44.89	39.95	8.45	2.01	4.70	52.24
11.1	10	0.3	36.41	43.73	15.86	3.36	0.64	50.70
11.1	10	0.4	25.13	56.53	15.33	1.58	1.42	38.82
11.1	10	0.5	23.82	58.47	14.83	1.86	1.03	37.05
11.1	9	0.3	42.43	31.08	14.77	2.11	9.60	54.01
11.1	9	0.4	32.92	49.80	11.98	3.32	1.98	43.24
11.1	9	0.5	26.62	60.06	9.48	2.34	1.51	34.90
11.1	8	0.3	45.69	40.07	5.60	5.89	2.75	50.40
11.1	8	0.4	38.37	49.07	5.10	3.51	3.95	42.63
11.1	8	0.5	27.92	65.38	4.56	1.29	0.86	32.15

However, at 4.2 % moisture content it increased with increase in clearance. A possible explanation for this could be that at 4.2 % moisture content, the grain being more brittle, broke less at higher clearances. This indirectly resulted in lower breakage and powder and was consequently reflected in terms of higher dehulled fraction.

The multiple regression analysis using MINITAB statistical package shows that the following second order model best described the variation of dehulling responses.

$$Yi = \beta_0 + \sum_{i=1}^{3} \beta_i X_i + \sum_{i=1}^{3} \sum_{j=i} \beta_{ij} X_i X_j$$

where,

Y_i = Dehulling responses; β_0 = Constant; β_i and β_{ij} = Coefficients; and X_i and X_j = Independent variables

The constant, coefficients, F value and R^2 value for the models are given in Table 3. The F value calculated for the models are greater than the F table value i.e. 3.29. The F values and higher R^2 values confirmed the acceptance of the models.

Effect of grain and machine parameters on dehulling responses of small size seeds : The dehulled fraction varied from 12.26 to 52.73 % with maximum being at 6.4 % moisture content, 8 m/s speed, 0.3 mm clearance and minimum at 4.2 % moisture content, 8 m/s speed, 0.3 mm clearance respectively. The fraction of unhulled seeds obtained was

minimum (0.21 %) at 4.2 % moisture content, 8 m/s speed, 0.3 mm clearance and maximum (65.38 %) at 11.1 % moisture content, 8 m/s speed and 0.5 mm clearance. The broken fraction obtained varied from 1.29 to 17.20 % with maximum being at 4.2 % moisture content, 10 m/s speed and 0.3 mm clearance and minimum at 11.1 % moisture content, 8 m/s speed and 0.5 mm clearance. The fraction of powder was maximum (67.36 %) at 4.2 % moisture content, 8 m/s speed, 0.3 mm clearance and minimum (0.86 %) at 11.1 % moisture content, 8 m/s speed and 0.5 mm clearance. The hull percentage was maximum (17.06 %) at 4.2 % moisture content, 9 m/s speed and 0.4 mm clearance, while it was minimum at 11.1 moisture content, 8 m/s speed and 0.5 mm clearance.

Dehulling efficiency values varied from 13.99 to 61.27 % with maximum being at 6.4 % moisture content, 8 m/s speed, 0.3 mm clearance and minimum at 4.2 % moisture content, 8 m/s speed and 0.3 mm clearance. The constant and coefficients of the mathematical models developed for these responses as a function of grain and machine parameters alongwith F values and R^2 values are presented in Table 4.

As explained earlier, the dehulling characteristics largely depend on the moisture content, peripheral speed and clearance between the rolls. Consequently, the milling responses for small size grains also followed a pattern similar to large size seeds.

Statistical analysis was also carried out to examine the total effect of individual variables. The analysis was a joint test on all the parameters, involving one particular factor at a time. For example, for moisture content, X_1, the hypothesis was tested that the terms for interaction (X_1X_2, X_1X_3) and X_1^2 are zero (Floros and Chinnan 1987). The results of this analysis for dehulled fraction are presented in Table 5.

It is evident that all the parameters affected the dehulled fraction recovery significantly. However, moisture content was the most critical parameter. This was followed by peripheral speed and the clearance. The clearance was significant only at 5 % level for large size seeds and at 1 % level for small size seeds. However, the effect of seed size was found to be statistically insignificant.

From the foregoing discussion, it may be concluded that the milling responses of rapeseed were influenced both by grain and machine parameters, the values of parameters for maximum dehulled product and dehulling efficiency being 6.4 % moisture content, 8 m/s speed and 0.5 mm clearance for large size seeds and at 0.3 mm clearance for small size seeds respectively. Moisture content was found to be the most critical parameter of these, while clearance was the least significant. A full second order mathematical model best described the variation of dehulling responses with grain and machine parameters.

TABLE 3. CONSTANT AND COEFFICIENTS OF THE MATHEMATICAL MODELS REPRESENTING DEHULLING RESPONSES FOR LARGE SIZE SEEDS

Constant/ coefficient	Dehulling responses: Dehulled	Unhulled	Broken	Powder	Dehulling efficiency
β_0	69	-10	-34.8	78.5	20
β_1	19.3	-3.4	-.3.63	-13.9	23.9
β_2	-13.0	11.9	10.5	0.3	-13.0
β_3	1.0	-219	59.3	-63.7	163
β_{12}	-0.283	0.434	0.173	-0.739	-0.00
β_{13}	-9.58	8.65	0.41	4.30	13.7
β_{23}	-0.17	-8.1	4.16	4.15	-2.7
β_{11}	-0.935	0.133	0.0405	1.01	-1.24
β_{22}	0.63	-0.45	-0.779	0.200	0.50
β_{33}	40	248	-98.2	-21.8	-51
F-value	12.89*	42.22*	15.89*	103.25*	15.34*
R^2-value	0.817	0.936	0.846	0.973	0.842

*Significant at 1% level F_T (9, 26, 1) = 3.29

TABLE 4. CONSTANT AND COEFFICIENTS OF THE MATHEMATICAL MODELS REPRESENTING DEHULLING RESPONSES FOR SMALL SIZE SEEDS

Constant/ coefficient	Dehulling responses: Dehulled	Unhulled	Broken	Powder	Dehulling efficiency
β_0	-177	5	29	472	-63
β_1	39.3	-11.3	4.68	-32.1	26.2
β_2	12.0	-3.4	-4.4	-55.1	12.5
β_3	206	206	-77	-376	-94
β_{12}	-0.726	0.3	-0.199	0.184	0.210
β_{13}	-21.5	19.5	-2.81	8.73	5.58
β_{23}	-6.75	-24.1	9.41	22.7	7.36
β_{11}	-1.68	0.626	-0.231	1.41	-1.76
β_{22}	-0.33	0.45	0.20	2.51	-1.01
β_{33}	-8	-73	-5	-104	28
F-value	20.00*	38.86*	4.67*	31.33*	22.60*
R^2-value	0.874	0.931	0.818	0.916	0.894

*Significant at 1% level F_T (9, 26, 1) = 3.29

TABLE 5. ANALYSIS OF VARIANCE FOR THE TOTAL EFFECT OF INDIVIDUAL VARIABLES ON DEHULLED FRACTION

Variables/ sources	Degrees of freedom	Total sum of of squares		Mean sum of squares		F-ratio	
		Large	Small	Large	Small	Large	Small
Moisture content, X_1	4	1420.64	2309.19	355.16	577.29	24.75*	42.85*
Peripheral speed, X_2	4	438.17	633.77	109.54	158.44	12.53*	11.76*
Clearance, X_3	4	207.35	601.89	51.83	150.47	3.26**	11.17*
Error	26	413.65	350.27	15.91	13.47		

*Significant at 1 % level F_T (4, 26, 1) = 4.14

** Significant at 5 % level F_T (4, 26, 5) = 2.74

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RESEARCH PAPER

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Development of a Rapid Test for the Enumeration of *Escherichia coli* in Foods

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All strains of *E.coli* possessing glucuronidase activity can be detected in 13 h by fluorescene when its substrate 4 methyl umbelliferyl β-D glucuronide (MUG) is incorporated in the growth medium. Solid and liquid media containing MUG were compared for the enumeration of *E.coli* in pure cultures and food samples Studies revealed very good correlation(correlation coefficient - 0.986) between the two methods of enumeration. Relationship between fluorescence detection time (FDT) and initial cell concentration of the inoculum was established. FDT was inversely proportional to the initial cell concentration. FDT of 1-13 h corresponds to cell concentrations of 10^9-10^1 cells/ml. A minimum of 10^8 cells/ml were required to produce visible fluorescence. A rapid single step method was standardised by adding 1 g of the sample directly to MUG containing broth and FDT was determined. Cell concentration was obtained from the graph (cell concentration v/s FDT). This method can be employed to enumerate *E.coli* in culture broth as well as food samples like raw meat, pasteurised milk and fresh/raw vegetables.

Keywords : *E.coli* test, Most Probable Number Method, Fluorescence test, Fluorogenic substrate, Fluorescence detection time, Single step method.

Rapid methods and automated analytical instruments for enumerating indicator organisms and diagnostic test kits for pathogens can be used in microbiology to screen samples and replace conventional cultural and confirmation steps. These alternative methods are based on modified conventional methods, instrumental measurement of bacterial metabolites, bioluminescence, immunological techniques, DNA techniques and combination of these techniques (Henk and Huis 1997). These methods are expensive, require sophisticated instruments and skilled personnel to perform the test. Moreover, literature on the simple, rapid and inexpensive tests for the enumeration of *E.coli,* an indicator as well as a pathogen, is scanty. But, culture media containing either fluorogenic (Damare et al. 1985) or chromogenic substrate (Restaino et al. 1990) have been employed for the detection of specific enzymatic activity in a microorganism. These media permit quick detection and identification of a specific organism by avoiding time consuming isolation tests and biochemical identification procedures. Such tests are useful in food processing industry where reliable, simple yet rapid tests are necessary to monitor the quality of raw materials, assess the presence of hazards at a processing point and also to test the end product for safety and quality assurance. Culture medium containing 4 methyl umbelliferyl β-D glucuronide (MUG) (Damare et al. 1985) has been employed for rapid detection of *E.coli*, a faecal indicator organism as well as potential pathogen. Efficacy of MUG containing agar medium was evaluated earlier (Srihari and Vijaya Rao 1998) for the detection of *E.coli* in processed foods. While doing so, it is essential to enumerate simultaneously. Fluorescent colonies could be detected on MUG agar after 18 to 24 h of incubation at 37°C. But when the counts are low, Most Probable Number (MPN) is the method of choice. But there are no reports available on the selective enumeration of *E. coli* using solid or liquid medium containing MUG. Hence, this investigation was taken up to i) compare the plate count and MPN method for enumeration ii) establish the relationship between the initial cell concentration and Fluorescence Detection Time (FDT) iii) develop a simple one step method for the determination of *E. coli* population.

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Materials and Methods

Food samples : Raw mutton available in city meat stalls, pasteurised milk from commercial dairies and raw vegetables from city market were procured and analysed immediately. Potable drinking water supplied in the laboratory was also analysed.

Bacterial test cultures : These included *E.coli* serotypes 0111:K58, 0126:B16, 044:K74 (The Staten Serum Institute, Copenhagen) and *E.coli* and *Salmonella* isolated from foods. All the test cultures were sub-cultured at 15 days intervals and maintained at 4°C on nutrient agar slants. Prior to use, the test cultures were grown on nutrient agar slants for 18 h at 37°C.

Microbiological media : MUG (Sigma Chemical Co, USA and HiMedia, India) and microbiological media (Difco Laboratories, USA and HiMedia, India) were obtained. All the other chemicals used were of AR grade procured locally. MUG agar containing peptone, tergitol, 4 methyl umbelliferyl β-D glucuronide and agar (Damare et al. 1985) and MUG broth were prepared as described earlier (Srihari and Vijaya Rao 1998). MUG broth was dispensed in 10 ml in screw cap tubes and sterilized. Plate count agar, violet red bile agar, nutrient broth and nutrient agar were prepared according to standard methods (Speck 1976).

All the test cultures mentioned above were streaked on PCA and MUG agar and inoculated into MUG broth for observation of growth and fluorescence. The efficacy of plate count and MPN methods were compared by enumerating the overnight nutrient broth cultures of *E.coli* on PCA, MUG agar and MUG broth.

Pure cultures of *E.coli* grown overnight in nutrient broth were serially diluted and plated on MUG agar and inoculated into 9 ml MUG broth in triplicate and incubated at 37°C. Broth cultures were observed for the appearance of fluorescence at hourly intervals. Time required for the first appearance of fluorescence (FDT) in various dilutions corresponding to different cell concentrations were noted. A comparison was made between FDT and cell counts.

Fresh meat, pasteurized milk, raw vegetables and water were analysed for SPC, coliforms (Speck 1976) and *E.coli* (Srihari and Vijaya Rao 1998). Ten grams in 90 ml of macerated samples were serially diluted and aliquots were plated on PCA, MUG agar and inoculated into MUG broth in triplicates. SPC of the samples and *E.coli* counts were noted. FDT was monitored by observing the fluorescence at hourly intervals. Simultaneously, MPN of *E.coli* was also determined.

One step method for enumeration of *E.coli* was also standardised using sample directly as inoculum. FDT obtained by adding 1 g or ml of the sample to 9 ml broth was compared with the *E.coli* count determined by plate count and MPN methods as per Speck (1976). Minimum number of cells required to produce visible fluorescence was established by determining the cell counts at FDT when initial levels of *E.coli* varied from 10^1-10^8/ml.

Inoculated MUG agar and broth were incubated at 37°C for 18-24 h and observed under UV at 366 nm for fluorescence in broth and fluorescent colonies on agar medium. PCA plates were incubated at 37°C for 48 h.

Correlation coefficient between the different parameters were calculated as per Pearson's coefficient of correlation (Gupta 1997).

Results and Discussion

Growth and fluorescence characteristics of cultures : All the test cultures grew well on PCA, VRBA, MUG agar and MUG broth. All the *E.coli* cultures showed fluorescence in MUG broth and MUG agar but none of the salmonellae showed fluorescence. It was reported that a few of salmonellae and shigellae exhibited fluorescence in MUG containing medium (BAM 1992). Eventhough Chang et al (1989) found that 15 % of the *E.coli* isolated from 35 food samples were glucuronidase (GUR) negative in MUG incorporated LST (Lauryl sulphate tryptose broth), only 2 % of them were GUR negative on MUG agar and MUG broth, which were later found to be enterohaemorrhagic *E.coli* (EHEC) as tested by sorbitol fermentation and Eijkman test (Doyle and Padhye 1989). Therefore MUG broth and agar could be used for the detection and enumeration of *E.coli* other than EHEC.

Efficacy of plate count and MPN method for enumeration: It has been reported (Srihari and Vijaya Rao 1998) earlier that whenever there was fluorescence in MUG broth, the subcultured growth and fluorescent colonies were confirmed to be *E.coli* by IMVC tests. But no work has been done on the comparison of the results obtained by the plate count and MPN methods. When the numbers are very small, MPN method is generally used for the enumeration (Speck 1976). In most of the foods. *E.coli* is found in small numbers. Therefore it would be more

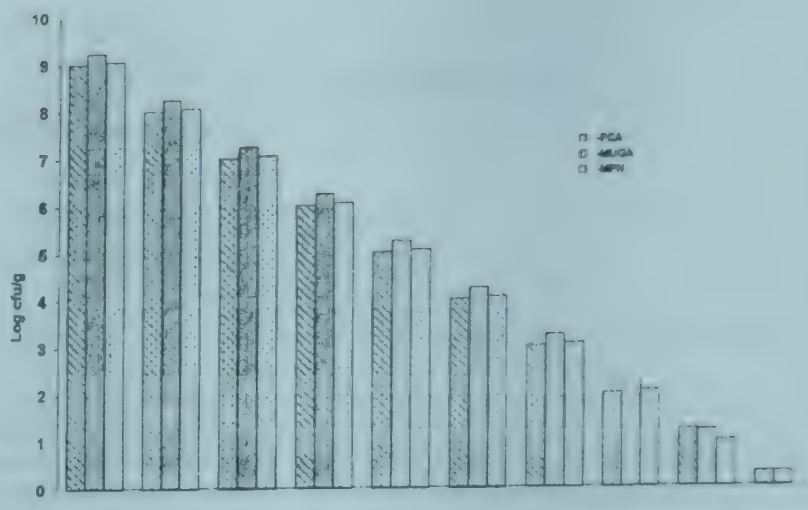

Fig. 1. Comparison of plate count and MPN methods for the enumeration of *E.coli*
Batches with different levels of inoculum from 10^9 and $<10^1$
C.C. PCA & MUG: 0.9997 C.C. PCA & MPN: 0.9995 C.C. MUG & MPN: 1.0000

appropriate to enumerate *E.coli* by MPN method than by colony count method. But, it was also reported that MPN method is less accurate (Harrigan and McCance 1976). Hence experiments with pure *E.coli* cultures were carried out to compare the results obtained by colony count method on MUG agar and MUG broth with that of PCA. It is evident from Fig. 1 that MPN values were slightly less than the counts on MUG agar, but more than those on PCA when the cell concentration were in the range of 10^2-10^9/ml. When the concentration was 10^1 and below, colony counts on both the agars were slightly more than the corresponding MPN values. The marginal higher counts on MUG agar could be due to error in counting the closely situated fluorescent colonies in the higher range of 25-250 or a plate from higher dilution with less than 25, but well scattered colonies. At low concentrations, total cfu on the plates would be less than the recommended statistically correct numbers (BAM 1992; Harrigan and McCance 1976). However, there was very good correlation between the results obtained by the three methods of enumeration as indicated in Fig. 1, the correlation coefficient being 0.9997 between PCA and MUGA counts, 0.9995 between PCA and MPN and 1.0 between MUGA and MPN values. Therefore, either of the methods could be used for the enumeration of *E.coli*.

Enumeration of *E.coli* in food samples

Results obtained for meat (70), milk (12), water (8) and vegetables (20) are given in Fig. 2-4. In meat samples, cfu of *E.coli* on MUG agar ranged from 2×10^1 to 6×10^7 which was comparable to the corresponding MPN values of 2.5×10^{-1} to 7.5×10^7. The same was true in the case of milk, water and fresh vegetables. Pasteurized milk samples had 4×10^1 - 2.5×10^5 cfu /ml of *E.coli* when the corresponding MPN ranged from 2×10^1 to -1.1×10^3. Out of the several potable water samples tested, only 4 samples had *E.coli* in the range of 1×10^1-6×10^2 and 4 - 9.5×10^1 when enumerated as cfu and MPN respectively. In vegetables, a variation of 1×10^1 - 7.6×10^4 of cfu/g and 4 - 4.5×10^4 of MPN was observed. In all the food samples, counts obtained by the two methods were comparable as seen with the pure culture. There was very good correlation between the MUGA counts and MPN values for the different

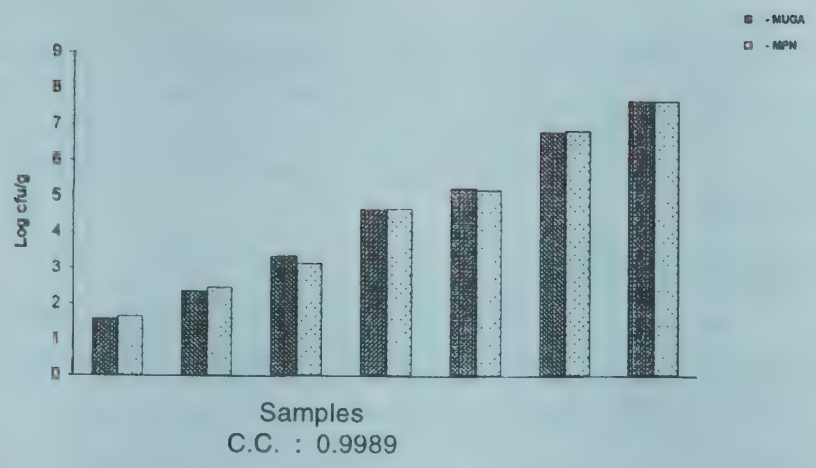

Fig. 2. Enumeration of *E.coli* in mutton by plate count and MPN methods

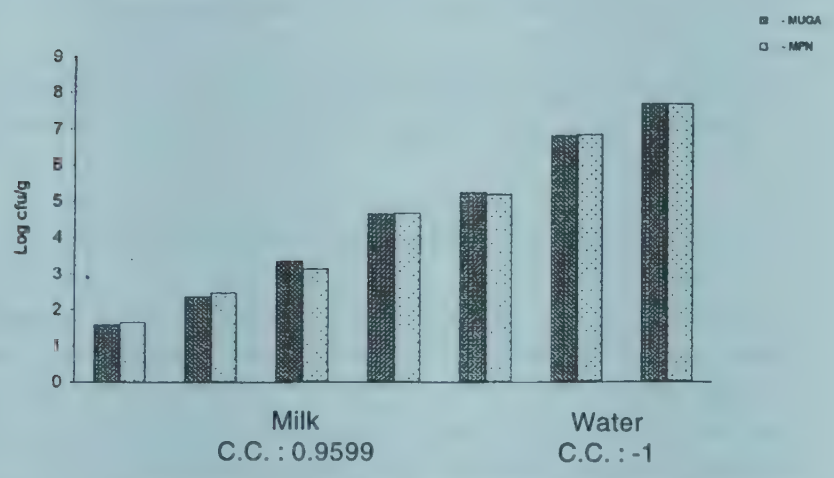

Fig. 3. Enumeration of *E.coli* by plate count and MPN methods

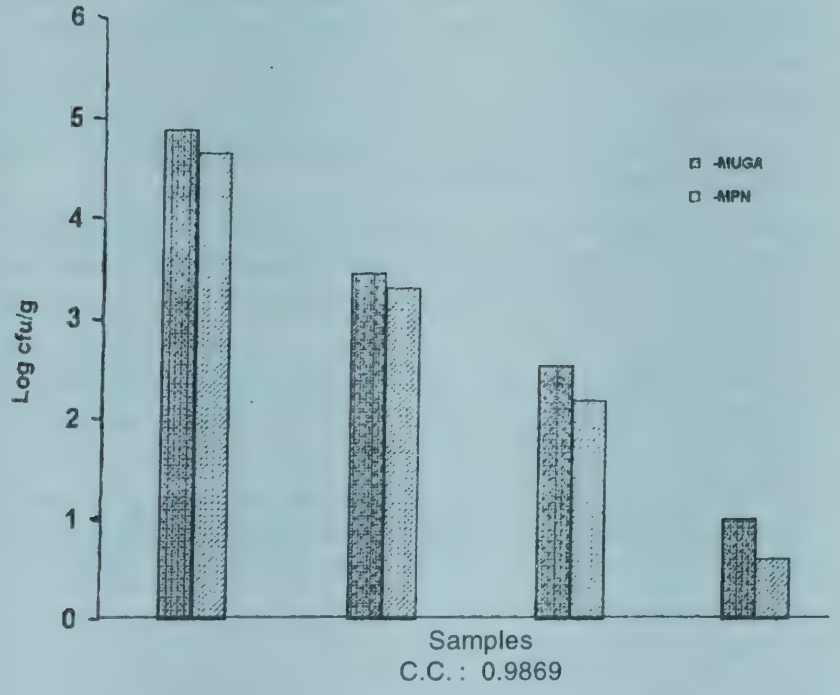

Fig. 4. Enumeration of *E.coli* by plate count and MPN methods in vegetables

sample types discussed. Correlation coefficients between MUGA counts and MPN values were 0.9989 for meat, 0.9995 for milk, 1.0 for water and 0.9869 for vegetables. Hence, MPN method can be successfully adopted for the enumeration of *E.coli* in food samples.

Relationship between FDT and cell concentration : Experiments were carried out using pure cultures to find out whether any relationship existed between the cell concentration and FDT and the results are presented in Fig. 5. Highest cell

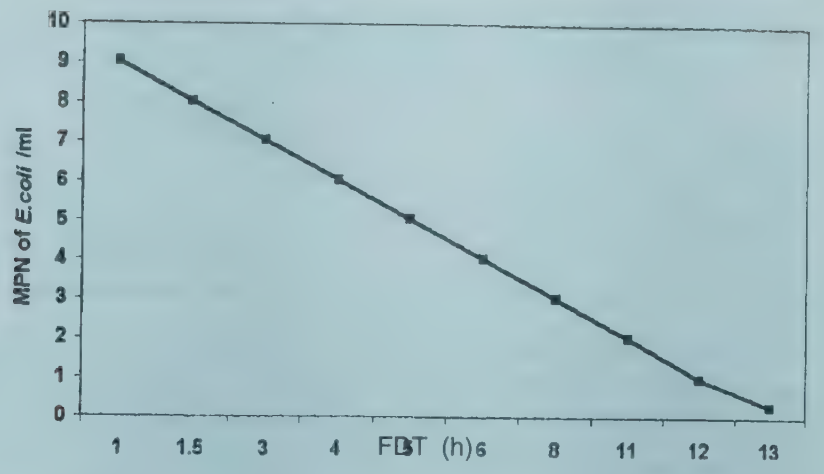

Fig. 5. Relationship between MPN and FDT
Correlation coefficient : -0.986
Each value is the average of 10 experiments

concentration tested was in the order of 10^9, which required just one hour to exhibit visible fluorescence. As the cell concentration decreased from 10^9 to < 10 cells/ml the detection time increased from 1 to 13 h. A linear relationship could be seen between the two, FDT being inversely proportional to the initial cell concentration which was substantiated by the correlation coefficient of - 0.986. This lead to the assumption that cell concentration should be built up to a definite minimum number to exhibit visible fluorescence. Cfu of culture broth with different levels of initial cell concentration were determined at FDT using pure cultures. Irrespective of the initial cell concentration, cfu at FDT were found to be in the order of 10^8/ml (Table 1).

Quality assessment of samples by FDT determination: Samples of meat (70), milk (12), water (8) and vegetables (10) were tested for cell numbers and FDT. Results are presented in Table 2. For meat samples with *E.coli* in the range of 10^2 - 10^4, FDT was in the range of 6 - 11 which were comparable to the results obtained with the standard cultures. Few samples

TABLE 1. DETERMINATION OF MINIMUM CELL CONCENTRATION OF *E.COLI / ml* AT FDT

Initial cell concentration, per ml	FDT, h	Cell concentration at FDT, per ml
1.8×10^1	11	5.2×10^8
2×10^3	7	6.8×10^8
2.5×10^5	5	6.1×10^8
1×10^7	3	5×10^8
3×10^8	2	6.6×10^8

TABLE 2. MICROBIOLOGICAL QUALITY AND FDT OF MEAT, MILK, WATER AND VEGETABLES (CFU/G OR ML)

Sample	SPC	Coliform	*E.coli*	FDT, h	C.C.*b/w FDT and *E.coli*
Fresh meat (70)	10^4 - 10^6	10^2 - 10^4	10^2 - 10^4	6 - 11	- 0.97575
Milk (12)	10^3 - 10^4	10^2 - 10^3	10^1 - 10^3	7 - 12	- 0.9599
Water (8)	10^3 - 10^4	10^1 - 10^2	10^1 - 10^2	11 - 13	- 1
Vegetables (10)	10^2 - 10^8	10^2 - 10^4	10^1 - 10^4	6 - 13	- 0.9869

C.C.* - Correlation coefficient

TABLE 3. ENUMERATION *E.COLI* BY DIRECT ONE STEP METHOD

		E. coli /g/ml	
Sample	FDT, h	Predicted	Actual
Mutton (30)	7 - 8	10^3	1 - 6 x 10^3
Vegetable (10)	10 - 11	10^2	1.7 - 4.2 x 10^2
Milk (10)	10 - 11	10^2	1 - 6 x 10^2

of milk and vegetables tested also gave similar results. But water samples exhibited slightly higher FDT than those for standard cultures or food samples. This difference in FDT might be due to the nature and type of organisms present in the samples. Hence, colony count and MPN methods could be successfully replaced by FDT method when fluorogenic substrate is employed for enumeration of *E.coli.*

E.coli as an indicator of overall quality : Several samples of meat, milk, water and vegetables had SPC in the range of 10^2 - 10^8 and the corresponding coliform and *E.coli* numbers were two logs less except for one or two meat and vegetable samples (Table 2). In one or two meat samples with SPC of 10^4 and coliform of 10^2, *E.coli* were 10^1/g. But, in one of the vegetables, SPC, coliforms and *E.coli* were 10^2/g, whereas in all the other vegetables SPC was in the range of 10^2 -10^8 with coliform and *E.coli* 10^2 -10^4/g. In general, there exists a definite relationship between SPC - the overall quality indicator and *E.coli.* But, SPC determination requires 48-72 h when *E.coli* could be detected just within 13 h by FDT method. As there is very good correlation between *E.coli* and FDT for all the food and water samples tested, FDT method could be conveniently employed for determining the overall microbial quality in 6 - 11 h for meat, 7 - 12 h for milk, 11 - 13 h for water and 6 - 13 h for vegetables (Table 2).

Direct one step method for the enumeration of E.coli: Experiments were carried out to assess the feasibility of using sample directly as inoculum instead of the extract (dilution). FDT and cell counts were determined and the results were compared with the predicted levels of *E.coli* (Table 3). Meat, milk and vegetable samples showed fluorescence in 7 - 8 h and 10 - 11 h, which predicted *E.coli* levels to be 10^3 and 10^2, when the actual numbers were found to be 1 -6 x 10^3, 1 - 6 x 10^2 and 1.7 - 4.2 x 10^2, respectively. This direct one step FDT method could be successfully used for the enumeration of *E.coli.* Since FDT could also indicate the overall microbial quality as discussed above, direct one step method could be successfully used for the rapid quality assessment of the given food samples which would replace large number of glassware, media and man power required for the conventional methods.

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RESEARCH PAPER

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Process Development for Production of Pure Apple Juice in Natural Colour of Choice

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In an experimental set up, a juicer procured from local market was modified in order that the inert atmosphere inside it was maintained and nitrogen gas was flushed during the process of juice extraction. For thermal inactivation of polyphenol oxidase, the temperature of the apple juice, just after its release from tissue could be instantly raised in shortest possible time to 80 - 85°C, followed by quick cooling to room temperature by circulating the juice through a helical coli of stainless steel tubing which would pass first through a hot water bath, then through a cold water bath under stipulated conditions. The process and equipment used are described. Using this equipment, apple juice could be obtained in three shades brown, slight pink and in natural shade with bright but light yellow tinge. The yield by this process was about 500 ml juice and 150 g dry apple powder per kg apple. The apple juice thus prepared was stable at room temperature. The juice could be easily stored for six months at 0-4°C. The organoleptic qualities of the three varieties of apple juice stored for three months at 0-4°C, were evaluated on a 9-point Hedonic scale. The three varieties were adjudged as good/very good with respect to various characteristics tested.

Keywords : Apple juice, Additive-free apple juice, Apple juice colour regulation, Browning regulation, Apple juice colour.

Consumers always prefer food material free from any chemical preservative or additive. This is especially true in case of food products like fruit juices which are expected to be additive free and close to natural characteristics. From a limited survey in the local markets of Mumbai, it was observed that many additives including preservatives and colour were being used in apple juice. These additives many times would mar the natural quality of juice mainly the taste and appearance. This observation prompted to develop a process in which use of any additive was completely eliminated, while at the same time retaining the colour and other attributes in their original form to the maximum possible extent.

Apple juice can be preserved in very pure state without having any additive in it. Its colour also can be controlled by regulating the enzymatic browning of the juice. The regulation is achieved by physical techniques. In these techniques, the enzymatic browning reaction is temporarily avoided by extracting the juice in the absence of oxygen, under inert atmosphere of nitrogen, which is immediately followed by permanent prevention of the reaction by inactivation of the polyphenol oxidase by thermal energy. Since in apple juice, colour development is due to enzymatic browning and to some extent leaching of colour from skin into juice, regulation of the two phenomena was attempted. The technique developed was very effective in controlling colour of apple juice, as a result of which, the juice could be obtained as a drink in three different colours, free from any additive in it.

Materials and Methods

Apple : Apples mainly 'Red delicious' available in Mumbai were used in this study. In few trials a small sized variety locally known as 'Saharangpur' variety were also used. The apples were stored at 0-4°C before use.

Juicer : A juicer, Mixer, Grinder Model No HL 3298 [Philips (India) Ltd.] was used to extract juice.

Modification of juicer : Under normal conditions, when juice is extracted from apple, it instantly turns brown due to enzymatic reaction. When this juice is bottled, the final product gets a brown shade.

Fig. 1 shows the laboratory scale experimental set up to preserve apple juice, in three different colour shades, without adding any external ingredient to it. The above unit had capacity to process 10-kg apples per hour to produce 5 liters of apple juice and pomace, which after drying can yield 1.5 kg dry apple powder.

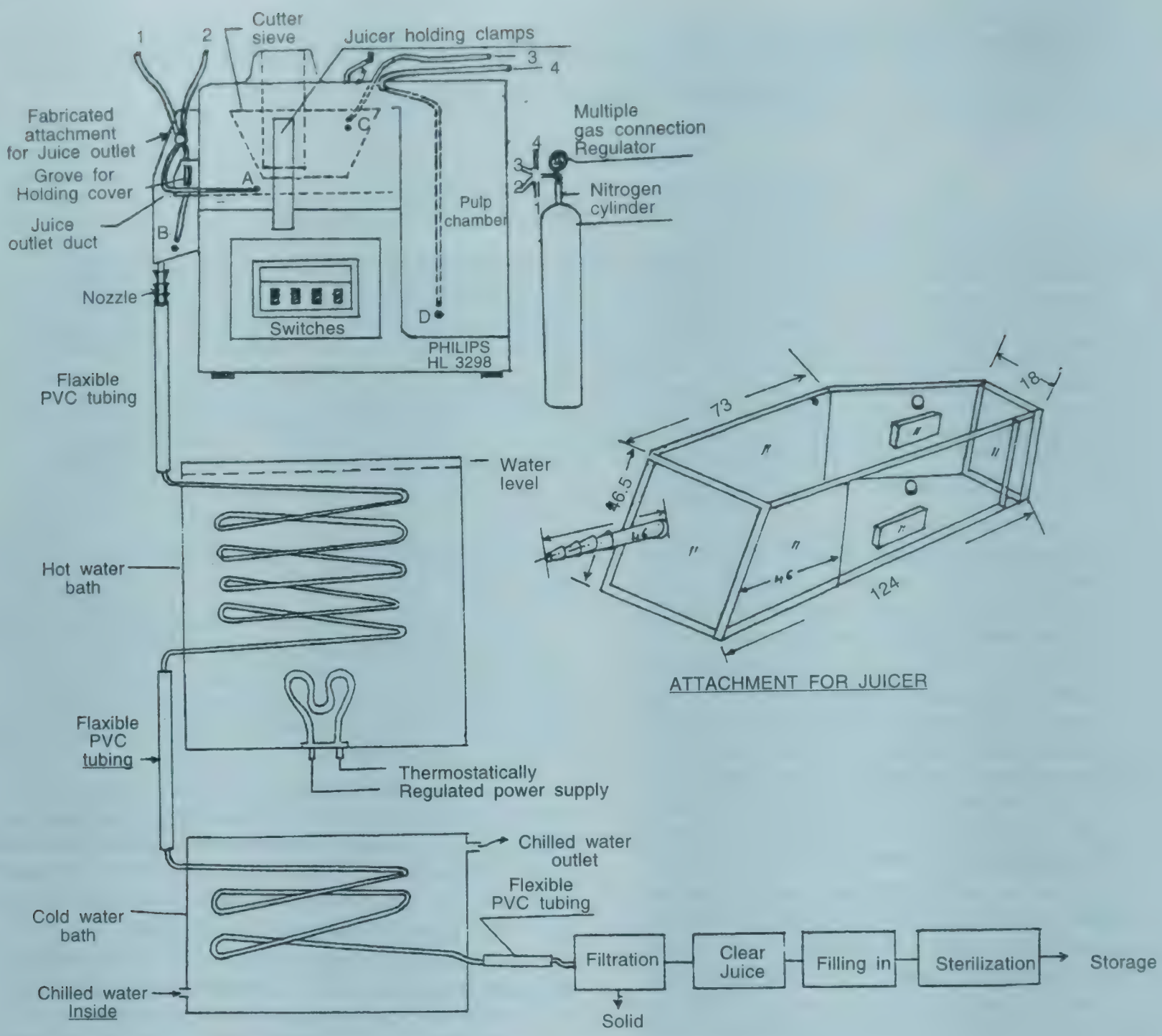
The limiting factor of this unit was that the capacity of compartment collecting the waste material and sedimentation of fine powdery sediments in juicer assembly, causing obstacle to rapid discharge of juice from juicer housing into outlet duct. Due to this, after processing of 4 kg, the debris and sediments were removed and the process was restarted.

To overcome the phenomenon of enzymatic browning, the air inside the juicer was replaced with nitrogen and an inert atmosphere was maintained in the juicer throughout the period of operation. Such situation was achieved by modifying the open outlet duct of the juicer by covering it with detachable a box type cover termed as an attachment having a nozzle fitted to it at the base. The attachment was designed and fabricated from 'Perspex' sheets. The attachment can easily be attached to or detached from the juicer outlet duct simply by pushing or pulling. Once the attachment was fixed, air could not enter through the juicer outlet duct as long as a positive pressure of nitrogen gas existed inside the juicer.

Two'Tygon' tubing of 1/32" ID and 3/32" OD well fitting into the hole, were inserted through the two holes provided on the attachment to introduce nitrogen gas into the attachment and juicer.

The attachment was connected to hot water bath through the flexible PVC tubing. The upper end of the PVC tubing is connected to the nozzle of the attachment, while the other end to the SS tubing passed through the hot water bath.

Method of flushing air inside the juicer with nitrogen : Nitrogen gas was distributed using a 5-point gas distribution



ATTACHMENT FOR JUICER

Fig. 1. Laboratory scale experimental setup/flow sheet of process

tubing as detailed in Fig. 1. Using this device, nitrogen was introduced at four critical points A, B, C and D as depicted in the figure. This ensured complete nitrogen atmosphere at i) just below the cutter sieve disc of the juicer ii) inside the attachment iii) just above the cutter sieve disc and iv) at the base of waste material collection chamber.

Hot water bath : The function of this unit was to increase apple juice temperature in shortest possible time. The drop of juice just after release from apple tissue entered into heat exchanger and before coming out of the unit it instantly attained a temperature of 80 - 85°C. Polyphenol oxidase (PPO), which catalyses oxidation of phenol leading to browning, got totally inactivated and the juice never turned brown.

The hot water bath consists of a thin walled cylindrical tank of 26 cm inside diameter and 26 cm height. A thermostatically regulated heating coil was provided at the center of the circular base (Fig. 1).

Stainless steel tubing of 6 mm inside diameter, 0.5 mm thickness having 5 meter length was rolled into a helical coil. The coil was having 25 cm mean diameter of the helical circle with a descending slope, 5 cm per turn. The total turns were 5 in number. The two ends of the SS tubing were brought out about 10 cm through the wall of the cylindrical tank. While the upper end was connected to the attachment, the lower end was connected to a similar tank through which chilled water was circulated instead of the hot water.

Cold water bath : This water bath was identical in design to the hot water bath but having no heating coil and the cooling coil was shorter in length. This bath was meant to cool down the juice to a temperature around 20-30°C.

Filtration : The juice coming out from the chilled water bath, contained some amount of fine particles which needed to be filtered out. In laboratory scale, because of small volume, the juice was first filtered through cheesecloth to

remove coarse particles, followed by removal of very fine particles by centrifugation.

Bottling and sterilization : The clear juice thus obtained was filled under nitrogen in 200 ml capacity bottles. The bottles were sterilized by keeping them in boiling water for 15 min. Storage of the bottles at room temperature did not show any microbial growth.

Spectrum of brown pigment formed in apple juice and measurement of degree of browning : Apple juice was extracted and kept in presence of air until brown colour was developed. The juice was centrifuged to remove insoluble solids and the spectrum of the brown pigment was recorded against the reference prepared as follow. Apple juice was extracted from the same lot of apples in absence of air or oxygen. The juice was collected in a conical flask (with stopper) flushed with nitrogen and containing pre-weighed quantity of the antioxidant sodium erythorbate to bring the final concentration to 25 mM. The clear solution obtained after centrifugation was used as a reference. The reference sample was prepared first and then the experimental.

The reference sample shows 0.3 O.D. at 390 nm with respect to distilled water. Hence in absence of any reference sample, browning of apple juice was measured by its absorbance at 390 nm with reference to distilled water minus 0.3.

Determination of the temperature required for inactivation of PPO : About 50-60 ml of apple juice was quickly extracted and collected under nitrogen in a stoppered conical flask having a thermometer and sample withdrawing arrangement. Immediately after extraction the flask was quickly transferred in boiling water bath. Samples (3 ml) were withdrawn from the flask at regular time intervals after noting its temperature at the time of withdrawing. The sample under test was transferred in a test tube kept in a water bath at 30°C. After allowing the full development of brown colour the test sample was centrifuged and the OD of the brown pigment formed in the clear fluid was read against distilled water at 390 nm using a Shimatzu spectrophotometer. Two graphs 1) temperature reached vs duration of heating and 2) absorbance at 390 nm as an index of residual browning potential vs duration of heating were plotted as depicted in Fig. 3.

Sensory evaluation : The three varieties of apple juice prepared in laboratory along with sample of two well known commercial brands of apple juice procured from local market were simultaneously served under stipulated conditions to a taste panel containing 36 judges. The above five apple juice test samples were simultaneously evaluated for five characteristics namely, appearance, colour, flavour, taste and overall acceptability on a 9-point Hedonic scale.

Operational procedure : The product can be obtained in three colour shade (1) Brown (2) Slightly pink and (3) Pale yellow, the natural shade of apple juice.

Whenever browning is to be eliminated, the attachment is placed at its proper position. The nitrogen carrying tubes were inserted properly up to the points A, B, C and D as shown in Fig. 1. Processing was initiated by switching on the hot water bath and raising the temperature of water in it to 95-96°C. Once the required temperature was attained nitrogen gas was flushed vigorously for about 1 or 2 min, till the air inside the juicer space is flushed out completely. Once this stage was reached, the flow rate of nitrogen gas was reduced to such a level which was just sufficient to maintain some positive level in the juicer so that no air from outside entered into the space inside juicer. Once such conditions were established, apples (stored either in freezer at 0-4°C or at room temperature) were cut one by one into pieces of the size, which could enter in the juicer. Within a minute or shorter time after cutting, the pieces were crushed in juicer after removing the seeds with help of knife or scoop so that there was very little chance for browning to occur.

Once the juice got released from tissues by the action of speedily rotating cutter sieve, the same was collected in juice collecting compartment filled with nitrogen. Because of non-availability of oxygen in it, browning reaction could not proceed and due to the slope in juicer housing, the juice automatically flowed under gravity and fell in the juicer attachment then through nozzle of attachment, into the inlet port of the hot water bath. As it started flowing due to gravitational force through the helical tubing submerged under water at 95-96°C, its temperature started increasing very rapidly with its further advancement. Once juice entered hot water bath it came out of it in just 30-40 sec with its temperature being increased from 30°C to 80-85°C.

Because of non-availability of small size, constant flow rate pump, gravitational force was utilized to circulate juice through the heat exchanger. However, pump was a better choice.

The hot water bath was designed in such a way that juice once entered in it, flowed continuously without resting in between, and under steady conditions, when juice was continuously fed without any break, the temperature of the juice coming out from outlet port would not deviate from 80-85°C. The hot juice was cooled to 20-30°C, while passing through chilled water bath.

Cleaning of tube in water baths : After completion of operations, water was flushed through tubing which removed all deposits inside the tubing. Holding hot NaOH solution in the SS tubing for some time, followed by flushing with water could carry out harsh cleaning, whenever found necessary.

Apple powder : Apple waste left after juice extraction was dried in an oven at 70°C, the dry mass was pulverized and then passed through a screen of proper mesh size.

Results and Discussion

Fig. 2 shows the spectrum of the brown pigment formed when apple juice is exposed to air, showing the maximum absorbance at 390 nm.

Fig. 3 shows the residual PPO, which caused brown pigment formation in the juice after keeping it at 30°C vs the highest temperature to which the juice was subjected during heating treatment to inactivate PPO. The curve showed that 80°C was the critical temperature once reached PPO present

in juice got practically inactivated. Mono phenol and di-phenolases (PPO) have been reported to be quite heat stable (Ullrich and Dupel 1975; Goodenugh et al. 1983). Temperature reported here was in full agreement with the data presented. Based on this study, the hot water bath was designed in such a way that under normal operating conditions where juice was expected to flow uninterruptedly at a rate of about 80-90 ml per min, each drop of juice attained a temperature of 80-85°C before coming out of the outlet.

Fig. 4 shows the various steps involved in processing apple juice to preserve it in three different colour shades. The brown shade of the juice was mainly due to enzymatic browning and to some extent due to the colour leached out from the peel. The leached colour subsequently changed its shade due to heat during sterilization process. The colour due to non-enzymatic browning during sterilization also got added to it and thus final shade was formed.

The pinkish coloured apple juice lacked totally the enzymatically formed brown pigment in it. However, it contained the colour that was leached out from peel into juice (which changed its shade during sterilization) and colour, which was developed due to non-enzymatic reactions during sterilization operation.

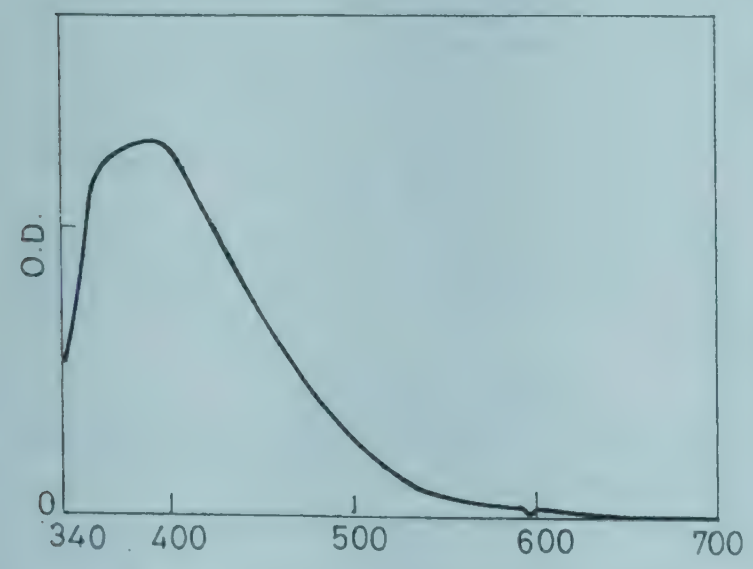


Fig. 2. Spectrum of enzymatically formed brown pigment in apple juice

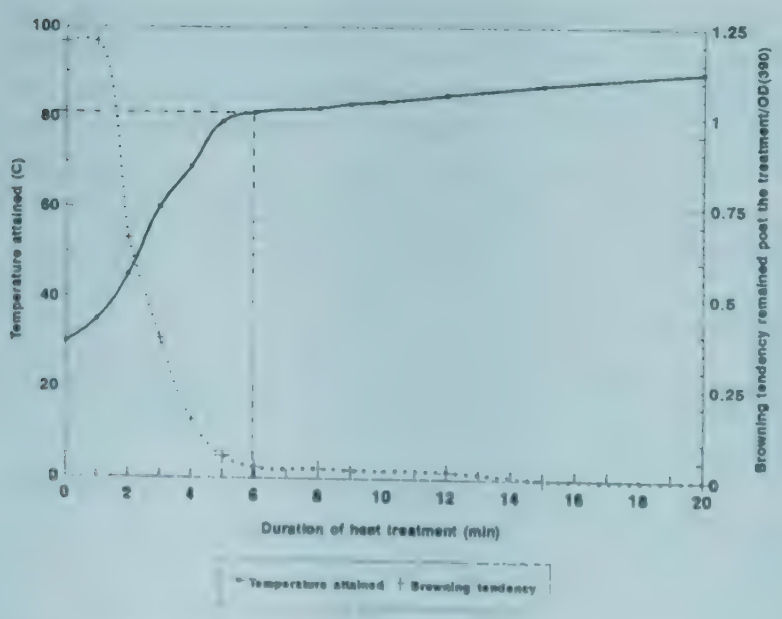


Fig. 3. Inactivation apple juice PPO by heat treatment

The third category juice lacked both the enzymatically formed brown pigment and the pigment, which got extracted from peel. The pale but bright colour of the juice was solely due to natural shade of apple tissue fluid with slight reddish tinge which got added due to the non enzymatic browning taking place during sterilization. The three samples could be stored at room temperature but low temperature was preferred for a longer shelf life.

Organoleptic evaluation : The data on organoleptic evaluation of the three products stored for three months at 0-4°C, along with two apple juice samples of known commercial brands are presented in Table 1.

As far as the appearance and colour were concerned the two apple juice types brown and pinkish scored the same points as those of market sample 1 (MKS-1) and market sample 2 (MKS-2). The third type the apple juice in its natural colour, scored marginally less than MKS-2. However, all the three varieties of apple juice scored between 6 and 7 i.e. between the quality mark "Good" and "below good but above fair" on the Hedonic scale. With respect to the characteristics flavour, apple juice in which browning was allowed showed the highest score among all the samples, followed by pinkish coloured, the natural coloured juice and then MKS-1 with very little margin. However, MKS-2 showed very low score as compared with the scores of the four samples.

The elimination of enzymatic browning reduced the score with respect to flavour from 7.49 to 6.63 and further the elimination of phenolic constituents, which were associated with peel, by the action of removal of peel reduced the score further down 6.63 to 6.53. Here the loss in flavour could also be due to the one extra heat treatment apart from sterilization, the pinkish and the natural coloured juices were undergoing for PPO inactivation. Apple is rich source of phenolic compounds (90-100 mg/100 g) (Mahajan 1994; Coseteng and Lee 1987; Bajaj et al. 1997). These compounds include catachin, pyrocyanidin, epicatechin, 4-methyl catechol, phorizin chlorogenic acid, naringin and rutin. The latter two are concentrated in peel (Coseteng and Lee 1987). The data obtained suggest the possibility of involvement of phenolic compounds and the associated browning reaction in development of flavour. PPOs and phenolic compounds are known to bė involved in development of flavour during tea (Rober 1958, Sanderson et al. 1976), coffee (Oliver et al. 1976, 1977) processing and in potato (Mondy et al. 1971).

Taste is the most crucial characteristic and all the three varieties under test showed the score around and slightly above 7('Good') on the Hedonic scale, whereas the market samples were lacking this quality, as the scoring was 5.97 (MKS-1) and 4.6 (MKS-2). Many panelists felt that the two market apple juice samples were sour in taste, especially MKS-2 was too much acidic although the claim on the pack was 100 % natural. All the three test samples were far better than the two market samples with respect to taste.

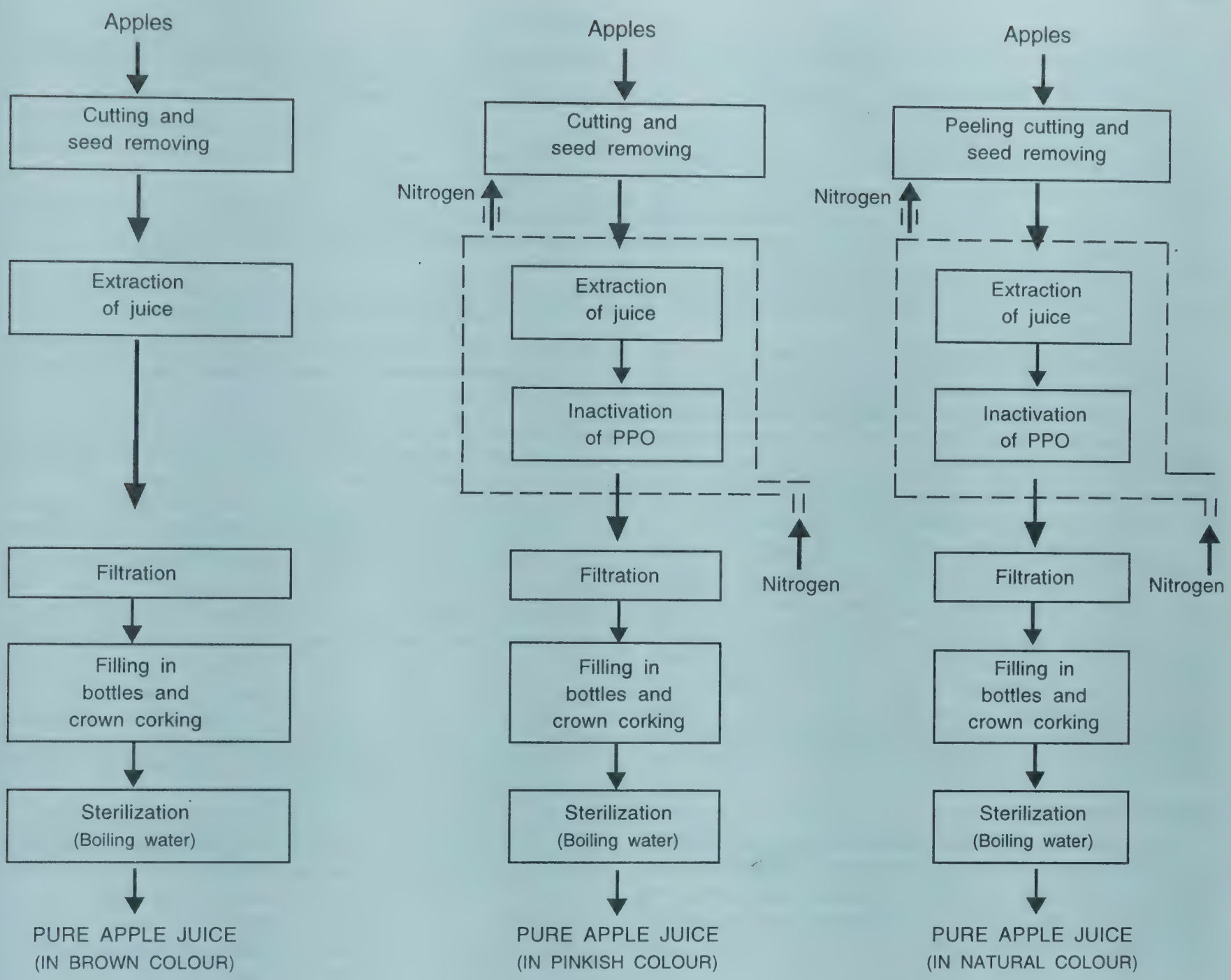


Fig. 4. Steps involved in the preparation of apple juice in three shades

As a result, in respect of the overall acceptance, the highest score was shown by the brown coloured juice (7.22), followed by pinkish sample (6.75), followed by the natural coloured juice (6.51), then MKS-1 (6.2) the least accepted was MKS-2 (4.78). MKS-1 contains lot of additives including caramel colour, while MKS-2 has been labelled as 100 % pure and 100 % natural.

TABLE 1. EVALUATION OF ORGANOLEPTIC QUALITIES OF APPLE JUICE SAMPLES

Apple juice samples	Characteristics*				
	Appearance	Colour	Flavour	Taste	Overall acceptance
Market samples :					
MKS-1	7.12	7.00	6.45	5.97	6.20
MKS-2	6.83	6.56	5.00	4.60	4.78
Laboratory test samples					
Brown	6.80	6.94	7.49	7.49	7.22
Pinkish	6.83	6.97	6.63	6.80	6.78
Natural coloured	6.43	6.15	6.53	6.94	6.51

*Organoleptic quality on 9-point Hedonic scale

Among the three-apple juice samples prepared in our laboratory, the best sample was the brown coloured juice, followed by pinkish one and the last the natural coloured apple juice. However, all these samples were superior to the two market samples MKS-1 and MKS-2 mainly due to taste and flavour. They were not in any way significantly inferior to the market samples with respect to the appearance and colour.

The process of preserving brown apple juice was very simple, consisting of extraction, filtration and filling followed by sterilization. This process did not need any special equipment or device, hence expected to be a cost effective. The organoleptic qualities or brown coloured apple juice were the best among the three types of juices, with the score around 7.0 on Hedonic scale.

However, if any change in colour shade of the juice was desired the process need to be modified with additional equipment and nitrogen gas facility, which will result in higher cost. At the same time, the change in processing was associated with marginal decrease in quality with respect to flavour and taste. This reduction in quality is partly due to the absence of browning reaction and partly due to the loss of flavouring compounds might be caused by degradation during heating of the juice to 80°C. From the results, it appeared that browning reaction might be contributing for development of flavour and taste because of which brown juice showed better score with respect to flavour.

The three products obtained were completely free from any of preservative or external ingredient. Hence, the natural taste of the three apple juice varieties was not marred or blanketed and very close to the natural taste of the fresh apple juice. This might be the reason why all the three juices showed higher score with respect to taste and to some extent with respect to flavour than the two market samples.

The assembly developed was in very primitive in nature but it depicted the basic principle very clearly. In place of using a pump, the gravitational force was utilized to circulate the juice through the heating and cooling systems. In the present system, quick heating and cooling systems were separate and independently operated, causing more energy loss. This energy loss can be minimized by using a single regenerative type of heating/cooling system, which is in regular use in pasteurization of milk or fruit juices.

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RESEARCH PAPER

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Effects of Structure Type, Orientation and Weather Conditions on the Inner Environment of Evaporatively Cooled Storage Structures

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The effects of type of storage structure, volume, materials properties, orientation and shading on the cooling effect of evaporatively cooled (EC) storage structures were studied with the help of a simulation model and limited field trials. The studies revealed that an EC storage structure made of permeable side walls maintained a considerably cooler environment than that in EC structures made of impermeable brick walls because of more amount of evaporation from the surfaces and infiltration through the side walls. The orientation has negligible effect on the internal thermal environment of the EC structures, both under shaded and unshaded conditions and the gains obtained by changing the long wall orientation from east-west to north-south was limited to only 0.6%. However, the cumulative heat units were lowered by 8.1%, 8.23%, 3.2% and 4.8% by shading the EC structure during the months of January, April, July and October, respectively, which represent the winter, summer, rainy and autumn seasons. The bigger structures maintained higher temperatures than smaller structures because of the heat generation of stored commodity and lower surface area to volume ratio. Hence, if artificial ventilation is not possible, it is better to have a number of smaller structures than a bigger one. In a properly designed EC structure, the inside relative humidity (RH) would remain more than 90% throughout the year, and the maximum advantage of evaporative cooling would be obtained under low ambient RH conditions, where the commodities can be stored for a longer period as compared to the ambient storage.

Keywords : Evaporatively cooled storage, Modelling, Thermal environment, Weather conditions, Storage structure, Volume, Orientation, Shading.

Design of an efficient evaporatively cooled (EC) storage structure for fruits and vegetables has been a matter of prime concern under Indian conditions (Rama et al. 1990). Though, a few types of EC structures have been developed and tested for storage of horticultural produce in India and abroad, it was observed that there was a gap between the potential cooling effect and the actual temperature drop obtained in these structures (Dash 1999). Though the small structures performed satisfactorily, the bigger structures of similar types of construction did not perform well under field conditions (Chouksey 1985; Roy and Khurdiya 1986; Hegde 1992). The effects of these structures also varied for different places and for different weather conditions. The reason might be attributed to the change in effects of different parameters like the structure size and materials of construction, under the influence of different thermal fluxes acting upon the EC structures. Hence, the present study was aimed at observing and analyzing the effects of these parameters for better understanding of the working principles of EC structures and design of such structures. Besides, the effects of weather conditions, structural orientation and shading were studied to prepare general guidelines for construction and operation of EC structures.

Materials and Methods

As analyzing the effects of each of the above parameters under consideration by conducting actual field experiments would be tedious and time consuming, the use of a simulation model accompanied by limited field trials was adopted for the study. A computer model has been developed by Dash (1999) for predicting the thermal environment in EC storage structures for horticultural produce. The parameters included in the analysis are the structural parameters such as size and shape, structural materials and their thickness; environmental parameters such as ambient temperature, RH, insolation and wind velocity; operational parameters such as rate of evaporation from the structural surfaces and infiltration through the structure; and different produce properties. The latitude and longitude of the place were considered in the model to determine the sunshine hours and solar radiation on the surfaces of the structure.

The computer model was validated with three EC storage structures of 1 m^3 capacity, one made of brick-sand-brick wall (Roy and Khurdiya 1986) and the other two with side walls made of wood wool pads sandwiched between wire meshes having length-breadth ratios 1 and 3 (Dash 1999). It was observed that the model adequately represented the thermal environment in these structures. Hence, simulation studies were carried out with this model to study the effects of some individual parameters such as type of storage structure, materials, storage volume, orientation and shading, and different weather conditions on the inner environment of the EC structures.

For comparative study of the temperatures obtained in different types of EC structures, the parameter called Cumulative Heat Units (CHU) was used (Dash 1999). It gave the daily sum of the product of average temperature of the enclosed air during a time step and the time step in hours. It had the unit of degree-hours.

$$CHU = \Sigma Ti\ (t).\Delta t \qquad \ldots\ldots (1)$$

The thermal properties of different components of the structure and its accessories, soil, stored produce and other

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relevant objects were taken from ASHRAE (1997), Holman (1997) and Hillel (1998), with confirmatory experimental validation. For simulations, the air velocity in the vicinity of the structure was assumed to be constant throughout the day at 2.5 m/s, and the heat transfer coefficients for different surfaces were determined as per ASHRAE (1997). The long axis of the structure was assumed to be oriented in East-West direction. The top surface was shaded. The amounts of total and diffuse radiations at any time during the experiments were obtained from Tiwari and Suneja (1997).

Results and Discussion

Effects of structure type, materials and dimensions : In the previous studies on extension of shelf life of horticultural commodities, mainly two types of EC storage structures have been used. The 'Zero energy cool chamber', which has side walls made up of two layers of brick with an annular sand layer (Roy and Khurdiya 1986) and its slight improvements have proved to be suitable for extending the shelf life of many horticultural commodities (Hegde 1992; IARI 1985). Habibunnisa et al (1988), Rama et al (1990) and Rama and Narasimham (1991) used EC chambers constructed of solid or perforated metallic sheets with evaporative pads/gunny cloth on the outer side. The side walls could also be made up of a layer of gunny cloth/wood wool pad for allowing infiltration of saturated air (Thompson and Kasmire 1981). The performance of these structure types and materials of construction for the same location and storage volume was compared with the help of simulation studies.

If the walls of the EC chamber are constructed with 1 mm thick mild steel plate or perforated sheet with 0.024 m thick gunny cloth/pad layer on it (assuming total thickness to be 0.025 m), then the thermal conductivity of the wall would be 2.22 W/m-°K. For a 2 mm thick metallic plate and 0.023 m pad, the thermal conductivity would be 4.34 W/m-°K. To study the effects of change in type of structure, the above two side walls were considered along with the brick-sand-brick side walls. The composite thermal conductivity of the brick-sand-brick wall, with 10 cm sand layer in between under saturated condition was taken as 0.92 W/m-°K (Chandra et al. 1999). The structures were considered to be of 1 m^3 volume with height 0.5 m and length-breadth ratio 1 for all the cases. The floor of the structure was considered to be made of a layer of brick on a 5 cm thick sand layer and the top cover of gunny cloth.

In the first attempt, for an intuitive understanding of the actual phenomena occurring in EC structures, the effect of only the material properties was considered without associating the wall thickness. All side walls were considered to be 0.025 m thick, as it would not be economical to construct metallic walls of more thickness such as the zero energy cool chamber. However, thin walls with low thermal conductivity could be easily constructed with suitable selection of materials. The infiltrations through all these structures were kept at similar level. The material properties related to radiation heat transfer were taken from ASHRAE (1997). The heat capacity of the materials were considered at two levels, i.e. 2.54 X 10^6 J/m^3-°K and 3.60 X 10^6 J/m^3-°K. It was observed that the thermal

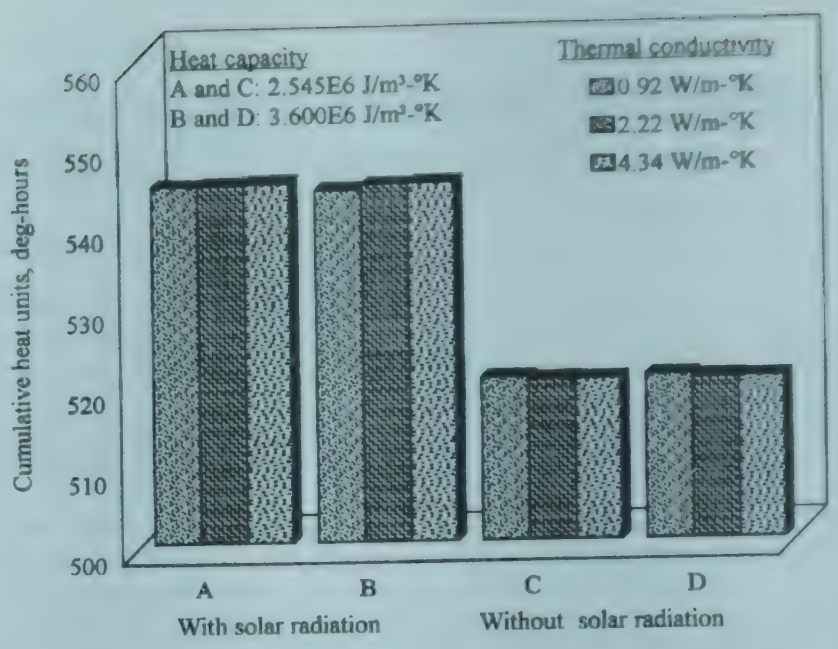


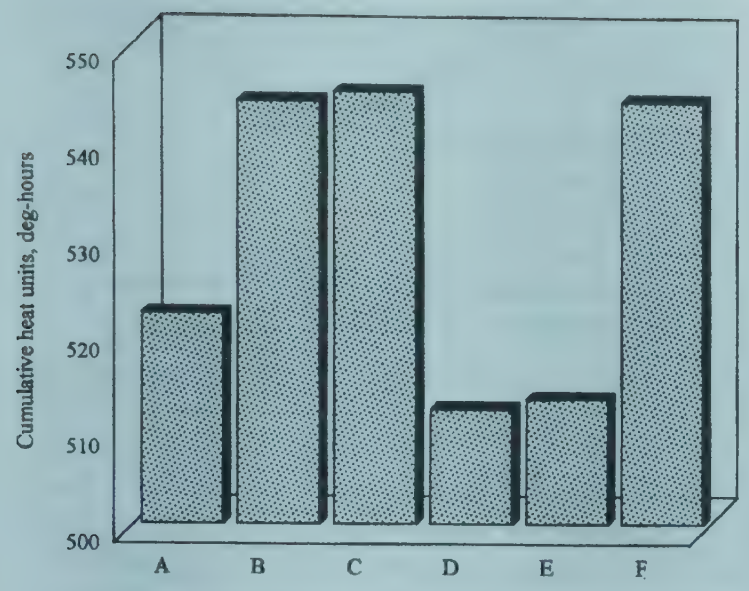
Fig. 1. Cumulative heat units in a 1 m^3 EC structure (with height 0.5 m, length-breadth ratio 1 and wall thickness 0.025 m) as affected by varying thermal properties of wall materials

properties of the materials did not have any significant effect on the internal thermal environment of the EC structures both with and without solar irradiation on the side walls (Fig. 1). Therefore, the effect of thermal conduction is quite insignificant in the overall heat balance of thin walled EC structures having same rate of infiltration.

However, in practice there would be considerable difference between the rate of infiltration through the brick walls and that in the permeable walls. Experimental studies revealed that the rate of infiltration for structures with permeable walls might reach up to 100 times of that obtained in the brick structures (Dash 1999). Hence, with this realistic assumption, the thermal environment obtained in five types of side walls construction (A: Two layers of brick with 10 cm thick sand layer, B: 1 mm thick mild steel plate wth an outer layer of wet gunny cloth, C: 2 mm thick mild steel plate with an outer layer of wet gunny cloth, D: Wire mesh covered with wet gunny cloth, E: 2 mm thick perforated plate with an outer layer of wet gunny cloth, and F: same as A, but with 5% potential evaporation from the side walls) have been compared and the results have been plotted in Fig. 2.

It was observed that the temperatures obtained inside the EC structures increased with increase in the thermal conductivity of structure walls under similar infiltration and evaporation conditions (comparison between A, B and C). However, when the metallic walls are made perforated or constructed of wire mesh, then the additional infiltration caused a reduction in inside temperature and the CHU. Under such a condition, the effects of wall thickness or thermal properties of the materials were insignificant (comparison between D and E).

In the above cases, it has been assumed that evaporation from all the surfaces in the structures was taking place at its full potential. However, the diffusion of moisture through the brick walls would reduce with passage of time due to deposition of salts. Dash (1999) also observed that the actual evaporation occurring on the outer surfaces of the brick walls was only 5 % of the potential evaporation in most parts of the day. In that



A : Side walls made of two layers of brick with 10 cm thick sand layer
B : Side walls made of 1 mm thick m.s. plate and wet gunny cloth
C : Side walls made of 2 mm thick m.s. plate and wet gunny cloth
D : Side walls made of wire mesh covered with wet gunny cloth
E : Side walls made of 2 mm thick perforated plate and wet gunny cloth
F : Side walls same as A, but with 5% of potential evaporation on the side surfaces

Fig. 2. Cumulative heat units in a 1 m³ EC structure as affected by the type of the structure walls

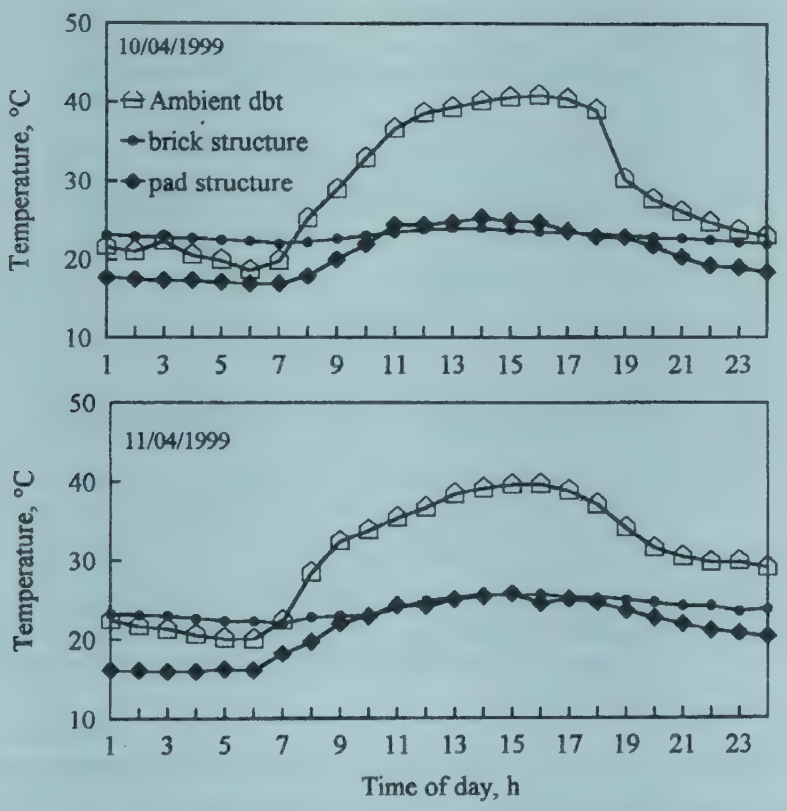


Fig. 3. Comparison between the observed air temperatures within the EC structures made of brick and porous pad on two test days

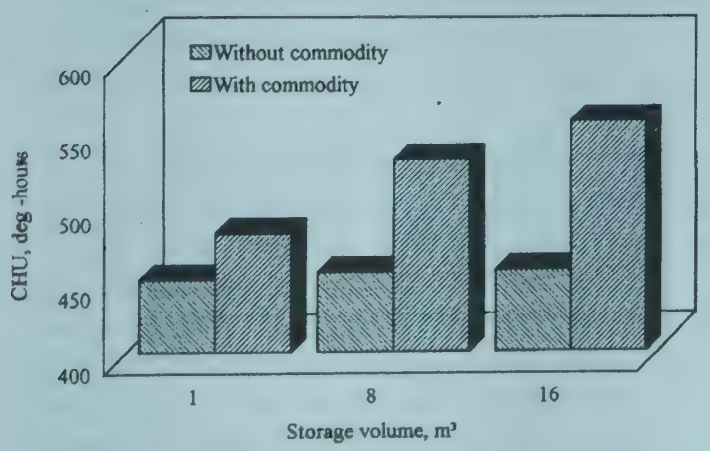


Fig. 4. Cumulative heat units as affected by the volume of the EC structure with and without commodity

case, the evaporation from the top surface and infiltration through different junctions contributed to the lower inside temperature, and the side walls served mainly as a barrier to the outside temperature fluctuations. With 5 % of the potential evaporation on the surfaces of the brick structure, the CHU was much higher than that obtained in a structure with permeable side walls (Fig. 2). A comparison between the temperatures recorded in two EC structures, one with permeable wall and the other with brick wall under similar environmental conditions confirmed the above findings (Fig. 3). However, the thicker walls imparted lower fluctuations in inside temperatures than the permeable thin walls, because of the higher thermal inertia. The RH in both the structures remained above 90 %, which is sufficient for extending the shelf life of perishable horticultural commodities (Thompson and Kasmire 1981).

Effect of storage volume : Simulations were carried out for 3 sizes of EC structures, 1 m³, 8 m³ and 16 m³, each having cubical configuration to know the effects of scaling up the structure. As observed in the previous section, the structures with permeable walls provided a better cooling effect than those with impermeable walls, and hence, only structures with permeable walls were considered. Analysis was made for both loaded and no load conditions. The produce was considered to be kept in bulk with 5 cm gap on sides and bottom and 10 cm gap at top. The study was carried out for a test day representing summer conditions.

Under no load conditions, the CHU increased by only 1.4 %, i.e., from 447.7 degree-hours for 1 m³ to 453.9 degree-hours for the 16 m³ structure, i.e. the temperatures almost remained same in all structures (Fig. 4). When the structures were loaded with produce (potato, in the present case), the air temperatures in bigger structures remained higher than that in smaller structures. The CHU of the 16 m³ structure was 15.8 % more than that obtained in the 1 m³ structure. It was because of the larger amount of commodity in bigger structures. The respiration heat generation of the commodity increased the inside temperature, which could not be released effectively from the chamber because of the lower surface area to volume ratio. Hence, if artificial ventilation is not possible, then it is better to have a number of smaller structures instead of one bigger structure. However, suitable provisions for increasing the ventilation/infiltration in bigger structures can reduce the temperature and CHU.

The amount of water evaporation from the surfaces increased with the volume of the structure (Fig. 5). However, the actual water supply to the structures should be higher to avoid any possibility of localized drying of the cooling pads/ gunny cloths.

Effects of structural orientation and shading : Dash and Chandra (1999) mentioned that the length-breadth ratio had a negligible effect on the inside thermal environment of EC structures. In that study, the long sides of oblong structures faced North-South and only the top surfaces were shaded. Hence, simulations were carried out for different weather conditions under two situations, viz. the structure kept outdoor with shading only on the top surface and the structure kept completely under shade. The effects of the structural orientation,

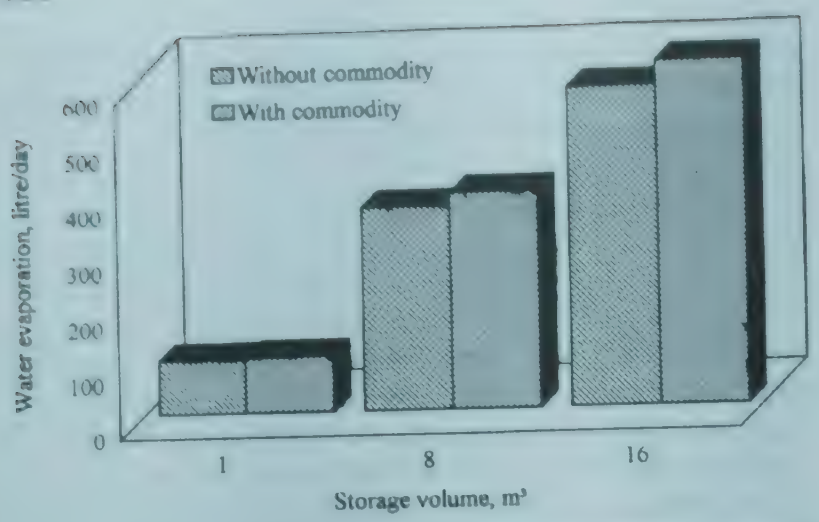


Fig. 5. Theoretical water evaporation from the surfaces of the EC structure as affected by storage volume and stored commodity

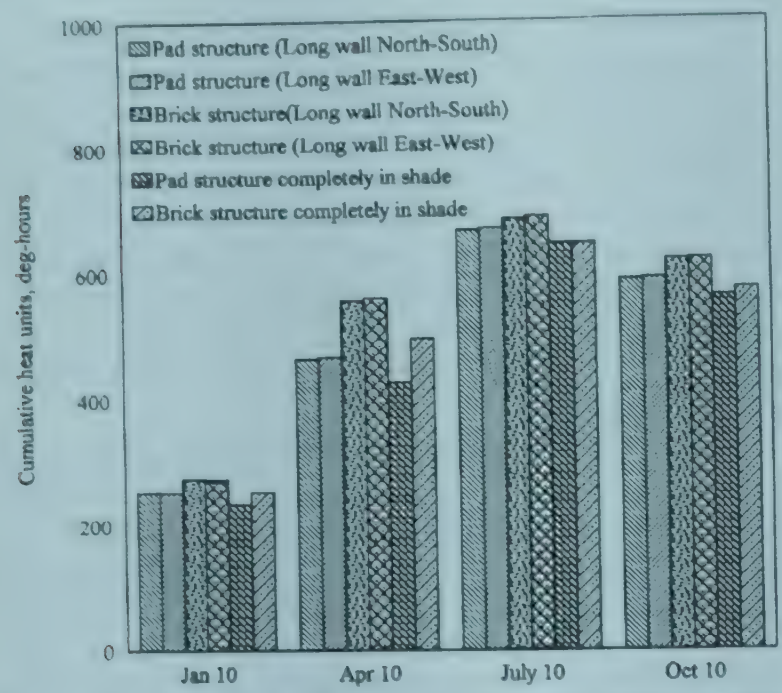


Fig. 6. Cumulative heat units in 1 m³ EC structures made of pad/brick side walls for different weather conditions and orientations

viz., the long walls facing either North-South or East-West were also quantified for top shaded structures. Both pad and brick structures with volume 1 m³, height 0.5 m and length-breadth ratio 3 were considered.

It was observed that the orientation of the structures had a negligible effect on the thermal environment in the structures (Fig. 6). However, the effect was more pronounced in April and July than that in October and January. The potential gains observed by changing the long wall from East-West to North-South for the pad structure were 0.6 %, 0.5 % and 0.3 % during April, July and October, respectively. A similar trend was observed also for the brick structure. However, during January, the CHU increased marginally by changing the long wall from East-West to North-South. This was because of the solar azimuth angle. Completely shaded structures showed a considerably lower CHU. The advantage obtained by shading the pad structure for January, April, July and October were 8.1 %, 8.23 %, 3.2 % and 4.8 %, respectively.

Effect of different weather conditions : As the structures with permeable walls offered lower temperatures than the structures with impermeable walls, only the former structures

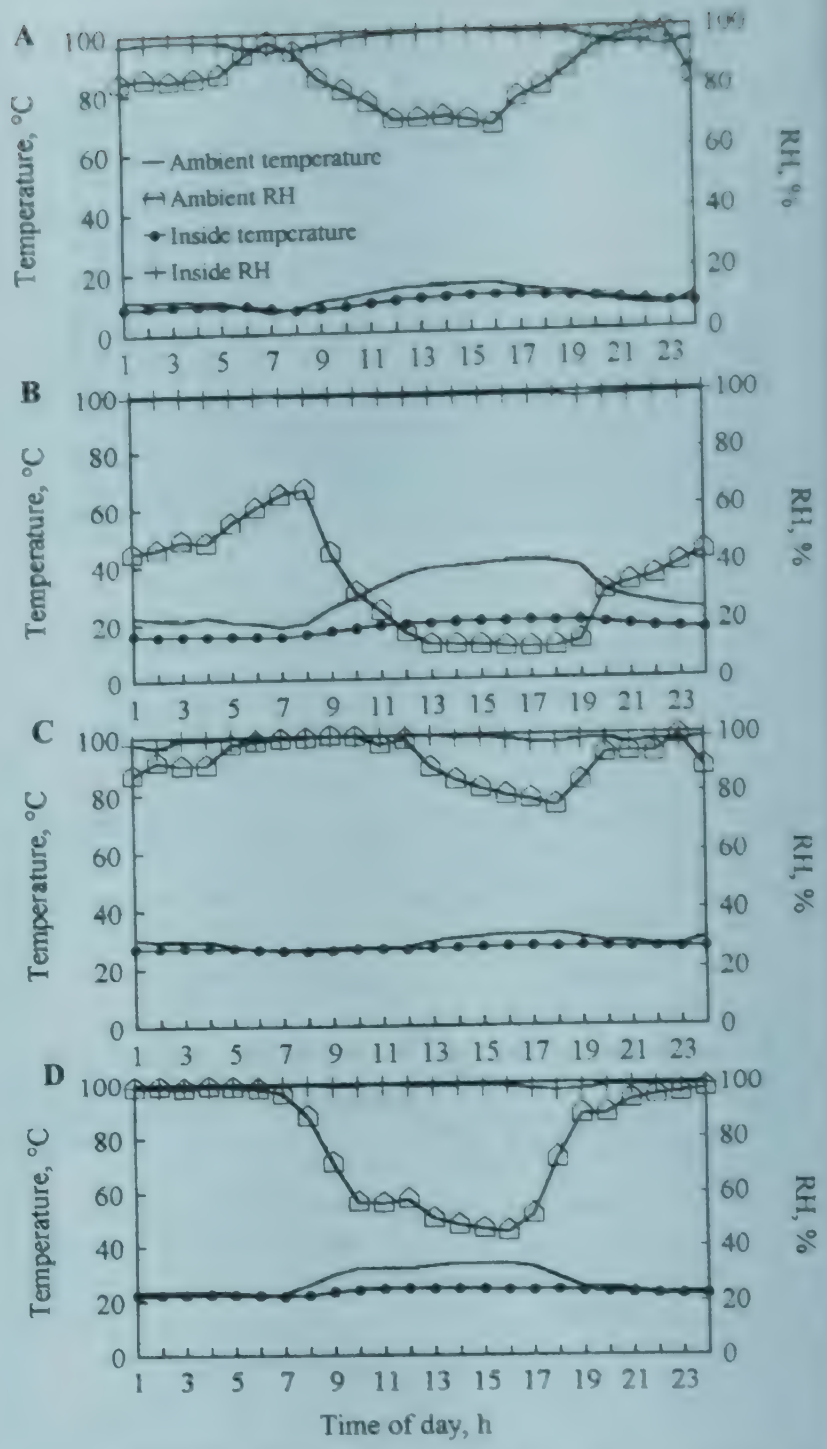


Fig. 7. Simulated thermal environment in a 1 m³ EC structure with pad walls A : Winter day (Jan 10, 1999), B : Summer day (Apr 10, 1999), C : Rainy day (July 10, 1999), D : Moderate day (Oct. 10, 1999)

having a volume of 1 m³ with height 0.5 m and length-breadth ratio 1 were used to observe the cooling effect in different weather conditions (Fig. 7). The difference in response between the pad and brick structures under same test day and location would be similar to that as shown in Fig. 3. The hourly weather data were taken from the automatic weather station at IARI, New Delhi.

It may be observed that on a winter day, when the ambient temperatures varied between 6.9°C and 15.4°C, the inside air temperatures were between 7.7°C and 11.7°C. For some parts of the day, when the ambient air was the coolest and the RH was almost close to 100 %, the inside temperature remained more than the ambient dry bulb temperature, which was due to negligible evaporative cooling on the surfaces and the thermal inertia effect. During April, as the RH was low during most hours of the day, a substantial temperature drop was

observed. During the rainy season, i.e., for a day in the month of July, the temperature drop was not very significant due to the lower wet bulb depression, and the inside temperature varied from 26°C to 27.4°C as against the ambient temperature variation between 26.4°C and 31.7°C. During a day in October, the ranges of outside and inside air temperatures were 22.7°C-33.7°C and 21.8°C-24.7°C. The inside RH of the structures during all parts of the year remained above 90 %.

A close examination of the above simulations revealed that the maximum effect of evaporative cooling would be obtained when the ambient RH remains at its lowest level, i.e., in summer months. During a day, the maximum temperature drop was obtained when the outside RH was at its lowest level, i.e. during afternoon hours. These are also the peak hours in terms of temperature. Hence, the EC storage structure will also prove to be advantageous if the day RH is at a low level even if the night RH is comparatively high.

Conclusion

A computer model was used to study the effects of type of storage structure, volume, material properties, weather conditions along with the structural orientation and shading on the thermal environment in evaporatively cooled (EC) storage structures. The EC structures with permeable walls maintained lower average temperatures and thus lower cumulative heat units (CHU) than those with impermeable walls because of more infiltration of saturated air. The thick walled structures had lower temperature fluctuations due to the thermal inertia. Under empty conditions, there was a negligible increase in CHU with increase in structural volume, however, for loaded conditions, the CHU of a 16 m^3 structure was 16 % more than that obtained in a 1 m^3 structure. The change in orientation of the structures changed the CHU by less than 1 %, whereas complete shading proved to be beneficial. The maximum effect of evaporative cooling would be obtained under low ambient RH conditions. As the harvesting season of most tropical fruits and vegetables coincides with the onset of summer (characterised by high temperature and low humidity), the evaporative cooling principle could be efficiently utilised for enhancing their shelf life as compared to other traditional storage practices.

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RESEARCH PAPER

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Physico-chemical Characteristics of Oil from Buffalo Gourd *(Cucurbita foetidissima)*

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The seed oil from Buffalo gourd *(Cucurbita foetidissima)* available in Pakistan was analysed for physico-chemical properties The extraction of seeds with n-hexane and chloroform-methanol mixture yielded 35.86% and 32.65% of oil, respectively. The oil was subjected to triple-refining at 65°C for 15 min. Bleaching was done at 105°C for 30 min. by using a mixture of activated bleaching earth (93%) and activated carbon (0.3%) and deodorized with 5% steam at 210°C for 120 min. Processed oil showed peroxide (0.2 meq/kg), conjugated unsaturated fatty acids (1.0%), saponification value (178.72), iodine value (139.59) and carotenoids (3 mg/kg) The degree of unsaturation in oil was around 10 %. Linoleic acid was the dominant fatty acid (64.48 %), followed by oleic acid (17.11 %). The oil contained a mixture of hydrocarbons (1.25 %), sterol esters (2.90 %), triglycerides (72.40 %), free fatty acids (2.20 %), 1,3-diglycerides (3.80 %), 1-2-diglycerides (4.20 %), sterols (1.20 %), 2-monoglycerides (3.50 %) and 1-monoglycerides (3.9 %).

Keywords : Buffalo gourd, *Cucurbita toetidissima, Seed oil,* Physico-chemical characteristics.

Cucurbitaceae or the Gourd family consists of about 10 genera and 800 species. It is mainly found in tropical of sub-tropical regions, with a few species extending into temperate climate. The seeds of three species of wild perennial gourds, *Cucurbita foetidissima, C.digitata* and *C. palmate* have commercial exploitation. Drying oils, high protein flour and chemically purified protein may easily be obtained from these seeds by standard procedures.

However, very little is known about their quality, chemical composition, fatty acids and essential oils of the seeds available in Pakistan. Alternate sources of vegetable oils and proteins are required for meeting the increasing demand for oils and proteins to growing population in the country (Weber et al. 1979). *C. foetidissima* H.B.K. is a wild xerophilous gourd, that is native to the Great Plains, the South Western United States and north Mexico (Sahani et al. 1951). *C. foetidissima* was introduced into Pakistan as a potential source of oil and proteins, which can be cultivated on arid and semi-arid lands (Bully et al. 1950). Its fruit is known as "Tuma" in Pakistan (Curtis 1946), which has medicinal value. Cultivation of such plants particularly in summer months, when large tracts of vacant land are available in Pakistan, is expected to help in bridging the oil and protein gap in the country.

Buffalo gourd seed is recommended for protection against colworm, tapeworm and seasickness (Markovic and Bastic 1976). The interest in growing the buffalo gourd in arid areas has been renewed in recent years (Vasconcellos and Berry 1976).

Curtis (1946) first recognized the economic importance of the seed of the buffalo gourd. Bolley et al (1950) characterized the oil as a "soft" drying oil having similarities to soybean oil. Berry et al (1976) reported that the whole seeds of *C. foetidissima* contained 33% crude fat and 32.9% crude proteins. Madeal and Lal (1984) studied the chemical composition of the kernels and the seed coats. They reported that cucurbita species compared well with some of the conventional kernels such as cashew nut and almond in their chemical composition.

The objective of this study was to determine the effects of processing conditions on the composition of buffalo gourd oil. The physical and chemical properties of the oil extracted from this xerophytic plant were also determined.

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Materials and Methods

C. foetidissima seeds were procured from the local market and the foreign matter consisting of hull fragments, stones and sticks were removed manually. The seed coats were yellowish grey and endosperm yellow in colour. The seeds were ground with the help of an electric grinder. Crude oil was extracted in n-hexane from 5.0 g samples, using Soxhlet apparatus with chloroform-methanol mixture. The extract was filtered and the oil was recovered after evaporating the solvent in a rotary evaporator.

Crude oil samples were subjected to refining, bleaching and deodorization under a variety of conditions. The effect of processing conditions on oil quality was determined by measuring carotenoids, free fatty acids, peroxide, conjugated unsaturated acids and oxidative stability. Triglyceride fatty acids were also determined. The oils were refined by treating with NaOH of different concentrations.

Bleaching was done with commercially available activated bleaching earth, natural bleaching earth and activated carbon individually or in combinations. Carotenoid content was measured spectrophotometrically. Oil samples were dissolved in cyclohexane (2.5% w/v) and the spectra were recorded in the range 350-500 nm. For the quantitative determination of total carotenoids, the absorbance was read at 417 nm. FFA (as percentage of total fatty acid composition), peroxide and the oxidative stability determinations were done by methods described in the AOAC (1970) methods.

Physico-chemical properties of lipids : The physico-chemical properties of the lipids were determined by standard AOAC (1970) methods.

Fatty acid analysis : The purified lipids were treated with boron triflouride-methanol reagent for half an hour, in a test tube with teflon lined screw cap for the formation of fatty acid methyl esters. The esters were purified on thin layer chromatography using hexane:ether (9.1 v/v) solvent system (Raj et al. 1983). The material was eluted and the solvent removed by distillation

TABLE 1. OIL RECOVERED FROM SEEDS OF *C. FOETIDISSIMA*

Extraction solvent	Oil recovered, %
n-hexane	35.36
Chloroform methanol mixture	32.69

TABLE 2. EFFECT OF REFINING ON THE CHARACTERISTICS OF REFINED OIL FROM *C. FOETIDISSIMA*

Refining methods	Caro-tenoid	Free fatty acids	Peroxide value, m.eq./kg	Long chain diene, %	Fatty acids triene, %
Crude oil	95.8	1.45	6.1	1.62	7.64
Single refining	76.2	0.24	13.2	1.59	4.8
Double refining	57.1	0.14	17.3	1.43	0.83
Triple refining	31.9	0.09	18.4	1.20	0.21

TABLE 3. EFFECT OF REFINING ON CHARACTERISTICS OF BLEACHED OIL FROM *C. FOETIDISSIMA*

Refining methods	Caro-tenoid	Free fatty acids	Peroxide value, m.eq./kg	Long chain diene, %	Fatty acids triene, %
Single refining	10.4	0.31	8.1	1.67	7.87
Double refining	8.9	0.38	4.2	1.50	3.54
Triple refining	5.7	0.42	3.8	1.29	1.2

TABLE 4. FATTY ACID COMPOSITION OF OILS FROM *C. FOETIDISSIMA*

Fatty acid	% of total fatty acids
Myristic	0.04
Palmitic	8.53
Stearic	7.87
Oleic	17.11
Linoleic	64.46
Linolenic	0.57

TABLE 5. EFFECT OF REFINING ON CHARACTERISTICS OF DEODORIZED OIL FROM *C. FOETIDISSIMA*

Refining methods	Caro-tenoid	Free fatty acids, % total	Peroxide value, m.eq./kg	Long chain diene, %	Fatty acids triene, %
Single refining	7.8	0.24	7.8	1.53	0.86
Double refining	6.5	0.16	5.2	1.24	0.48
Triple refining	6.0	0.10	4.2	0.89	0.41

to get purified methyl ester. Fatty acid methyl esters were analysed by gas liquid chromatography using polyethylene glycol succinate (10%) column (152.4 cm x 0.95 cm) coated on "diatomite C" (80-100 mech). Nitrogen was used as carrier gas with flow rate of 40 ml/min. The fatty acids were identified by comparison with their retention time with the known methyl ester standards.

Natural lipids were separated by thin layer chromatography using n-hexane : ether : acetic acid (80:20; v/v) and chloroform : methanol:) ammonia solution (60:35:2.5 v/v) solvent system (Wahid et al. 1981). The saturated solution of antimony tri chloride in chloroform was used for the identification of sterols and sterol esters. The reagents molybdenum blue, Dragondorff and ninhydrin were also used for the identification of phospholipid, phosphatidyl choline, phosphatidyl and lysophosphatidyl ethanolemine, which showed blue, straw orange and red-violet spots respectively in TLC.

Results and Discussion

The extraction of solids with n-hexane yielded 35.36% oil, while that from chloroform-methenol mixture yielded 33% oil (Table 1). The effects of using single, double and triple refining on oil composition before bleaching and deodorization are shown in Table 2. The results indicated that carotenoids and FFA decreased during refining. Refining did not have any significant effect on the total conjugated fatty acids, but the amount of dienoic and trienoic species decreased. These effects have been observed not only during refining of edible oils but also during other unit operations to which oils are generally subjected. The results also indicated that there was an increase in the peroxide value (PV). The effect of refining on bleached oils (with 2% super activated carbon) at 105°C for 30 min was determined (Hilditch and Williams 1964), the results of which are shown in Table 3.

The results showed that the carotenoids decreased during bleaching. It indicates that the adsorption capacity of the bleached earth was independent of the refining process used. The concentration of pigments in the oil samples subjected to triple refining were nearly the same (3.7 and 5.9 mg/kg).

An increase of FFA during bleaching process was noted. It was further noticed that the increase was more in double and triple refined oil as compared to the oils refined with 16° Be NaOH in a single step. Bleaching did not have any effect on the acidity of oils. It has been reported earlier that activated bleaching earth may decompose soaps that absorb the sodium ions and leave FFA (Bemis et al. 1967). The bleached oils showed no significant changes in conjugated fatty acids in comparison to the refined oils. Peroxide values were lower than the corresponding refined samples. The indigenous peroxides existing before refining of the oils or those formed during oxidation reactions, are known to be extensively destroyed during the bleaching process (Chaudhary et al. 1955).

Gas liquid chromatography analysis showed that the oils from seeds of *C. foetidissima* had high levels of unsaturated fatty acids. Linoleic acid was found to be the dominant fatty acid with 64.46% followed by oleic acid 17.11% (Table 4). These results support the earlier study by Bemis et al (1967), who reported 80% unsaturation and 60-65% linoleic acid content in the oil extracted from *C. foetidissima*. This polyunsaturated acid is an essential dietary requirement for humans and animals.

The effect of deodorization on bleached samples with 5% steam at 210°C for 120 min was studied. Properties of the deodorized oil are given in Table 5 and the overall properties of the refined oil summarized in Table 6. The specific gravity 0.9185 and refractive index of 1.462 at 20°C reported here are similar to values reported for oils obtained from *C. foetidissima* seed grown in different regions of Pakistan. The iodine value

TABLE 6. PHYSICO-CHEMICAL CHARACTERISTICS OF OILS FROM *FOETIDISSIMA*

Moisture, %	6.62
Ash, %	0.014
Refractive Index	
at 20°C	1.462
at 40°C	1.463
at 60°C	1.458
Specific gravity at 25°C	0.9185
Colour	Light
Acid value	0.20
Free fatty acids, % total	0.10
Iodine value	139.59
Saponification value	176.72
Unsaponifiable, %	2.00
Fixed seed oil, %	35.36

TABLE 7. COMPOSITION OF NEUTRAL LIPIDS OF *C. FOETIDISSIMA* AS DETERMINED BY TLC

Lipids	(%)
Hydrocarbons	2.3
Sterol esters	3.9
Triglycerides	72.4
Free fatty acids	3.2
1,3-diglycerides	3.8
1,2-diglycerides	4.2
Sterols	2.2
2-monoglycerides	3.5
1-monoglycerides	3.9

139.9 of the oil indicates the presence of unsaturated fatty acids. The saponification value of 176.72 showed that the oil contained longer chain fatty acids. The free fatty acids 3.2 indicated that the quality of the oil obtained was satisfactory. Analysis by thin layer chromatography (TLC) showed that the major constituents of the oil were triglycerides (72%) (Table 7). The other lipids that were identified by thin layer chromatography were hydrocarbons, sterol esters, 1-3-diglycerides, 1-2-diglycerides and free fatty acids (Table 7).

It may be concluded that *Cucurbita foetidissima* could provide an alternate source of edible oil.

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RESEARCH NOTE

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Storage Stability of Jack Fruit (*Artocarpus heterophyllus*) RTS Beverage

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Ready-to-serve (RTS) beverage was prepared from two varieties of jack fruits with 10 % pulp, 18° B TSS and 0.25 % acidity (citric acid) and packed in coloured (green) and colourless bottles and stored at room temperature to study the storage stability. The storage study showed that there was an increasing trend in the acidity and reducing sugar and decreasing trend in pH, total sugar, ascorbic acid and β-carotene content, but TSS did not change during storage. Retention of ascorbic acid and β-carotene contents were much better in the samples stored in green coloured bottles. The sensory quality attributes were found to be highly acceptable even after storing for 6 months at room temperature.

Keywords : Jack fruit (*Artocarpus heterophyllus* Lam.) RTS beverage, Chemical constituents, Package, Storage, Sensory quality attributes.

Fruit juice beverages and fruit juices are becoming popular due to their pleasing flavour and nutritional characteristics. RTS beverages have been increasingly gaining popularity throughout the country. These RTS beverages have been successfully prepared from different fruits such as mango, kinnow, watermelon, apricot etc., (Beerh et al. 1989; Ranote et al. 1993; Teotia et al. 1977; Manan et al. 1993) Jack fruit (*Artocarpus heterophyllus* Lam), a popular tropical tree is widely cultivated in Kerala, Tamil Nadu, some places of Andhra Pradesh, Central Maharashtra and Bengal (Saibaba 1996). The present study was undertaken to utilize jack fruit for the preparation of RTS beverage and to study the storage stability and consumer acceptability of the beverage.

Ripe sound jack fruits ('Local' and 'Vellipala' varieties) were purchased from the local market. The bulbs (carpels) were removed from fibrous mesocarp. The carpels were separated from seeds with seed coat and cut into pieces, pulped and passed through hand pulper. RTS was prepared to contain 10 % pulp, 18° Brix TSS (using sugar), 0.25 % acidity (as citric acid) as per the FPO specifications. Sugar was dissolved in required quantity of water and filtered to remove the impurities. The jack fruit pulp and citric acid were mixed in the sugar syrup, heated to 80°C, hot filled in the presterilized (300 ml capacity) colourless and green colour bottles, crown corked, pasteurized in boiling water bath for 20 min, cooled and stored at room temperature. The samples were subjected to chemical analysis and sensory evaluation at monthly storage intervals. Total soluble solids (°Brix) was determined by hand refractometer, acidity, reducing and total sugars were determined by the method outlined by Ranganna (1985). pH was determined according to the method prescribed by Hart and Fisher (1971). β-carotene was analysed by NIN procedure and ascorbic acid was estimated as per the procedure described by Mahadevan and Sridhar (1982). The sensory evaluation was done by 10 untrained judges after an interval of 30 days. The Hedonic scale used to grade the RTS ranged from 1.0 to 4.0.

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The changes noted in the physico-chemical constituents with jack fruit RTS packed in colourless and green colour bottles during storage period are given in Table 1. The data for each chemical change was collected at each month. But for discussion, the initial, 90 and 180 days of storage have been taken. From the results, it could be seen that TSS (18° Brix) of the RTS prepared from both the varieties stored in different glass bottles were found to be consistent throughout the storage period. Similar observations have been reported by Hegazi (1985) in RTS beverage from passion fruits. There was slight increase in acidity (citric acid) and a decrease in pH of the samples stored in different containers during storage. The RTS prepared from 'Vellipala' packed in either of the bottles exhibited slightly higher acidity throughout the storage period than the samples of 'Local' variety. Similar increasing trend in acidity was observed in the mango RTS beverage by Beerh et al (1989) and decreasing trend was reported by Chakraborthy et al (1993) in the watermelon RTS.

A considerable reduction in the total sugar content was observed during storage. The samples stored in colourless bottles exhibited a slightly higher loss of total sugar than the samples in green colour bottles. There was a steady increase in reducing sugar content in the RTS beverage as the storage period increased. The rise in the levels of reducing sugar content is apparently due to the conversion of non-reducing sugar, owing to the process of hydrolysis. Similar pattern of decrease in total sugar and increase in reducing sugar was observed by Beerh et al (1989) in the mango RTS beverage during storage. Significant differences had been observed while analysing the data statistically for acidity, total and reducing sugars.

A significant difference had been observed in respect of ascorbic acid in jack fruit RTS beverage at room temperature during storage. Retention of ascorbic acid content was higher in the samples stored in green colour bottles than in colourless bottles. Between the two varieties, the RTS prepared from 'Vellipala' had maintained slightly higher ascorbic acid content than the 'Local' variety throughout the storage period. Teotia et al (1997) noted a decline in the ascorbic acid content of muskmelon RTS beverage during storage (6 months). It was

TABLE 1. CHANGES IN CHEMICAL CONSTITUENTS IN JACK FRUIT RTS BEVERAGE DURING STORAGE

Storage period, days	Packaging container	TSS, °Brix		Acidity, g/100 ml		pH		Total sugars, g/100 ml		Reducing sugars, g/100 ml		Ascorbic acid, mg/100 ml		β-carotene, µg/100 ml	
		V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
0	Initial	18	18	0.250	0.250	5.75	5.74	15.67	15.89	5.81	5.87	5.85	5.91	15.00	17.50
90	T_1	18	18	0.261	0.261	5.69	5.68	14.69	14.97	6.14	6.20	3.26	3.86	8.13	11.30
	T_2	18	18	0.259	0.260	5.71	5.69	15.31	15.13	6.11	6.26	3.60	4.14	11.38	15.00
180	T_1	18	18	0.279	0.285	5.61	5.69	14.46	14.12	6.36	6.35	1.55	2.06	6.30	7.88
	T_2	18	18	0.270	0.277	5.62	5.63	14.72	14.24	6.29	6.36	2.10	2.81	7.50	10.05
SED		0.10068		0.01390		0.92627		0.70733		0.63732		0.1459		0.1275	
CD		0.20500		0.02831		1.88679		1.44082		1.29821		1.0297		1.0561	

TABLE 2. CHANGES IN ORGANOLPETIC CHARACTERISTICS OF SCORE VALUES OF JACK FRUIT RTS BEVERAGE DURING STORAGE

Storage period, days	Appearance				Colour				Flavour				Taste				Overall acceptability			
	'Local' (V_1)		'Vellipala' (V_2)		'Local' (V_1)		'Vellipala' (V_2)		'Local' (V_1)		'Vellipala' (V_2)		'Local' (V_1)		'Vellipala' (V_2)		'Local' (V_1)		'Vellipala' (V_2)	
	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2
0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
30	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
60	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
90	3.7	3.9	4.0	4.0	3.7	3.9	4.0	4.0	3.9	3.9	4.0	4.0	3.9	3.9	4.0	4.0	3.8	3.9	4.0	4.0
120	3.7	3.8	3.8	3.9	3.6	3.9	3.9	3.9	3.7	3.8	4.0	4.0	3.8	3.8	4.0	4.0	3.7	3.8	3.9	4.0
150	3.6	3.7	3.8	3.9	3.6	3.7	3.8	3.8	3.7	3.7	3.8	3.9	3.7	3.7	3.8	3.9	3.7	3.7	3.8	3.9
180	3.5	3.6	3.8	3.9	3.5	3.7	3.8	3.8	3.6	3.6	3.7	3.9	3.6	3.7	3.7	3.9	3.6	3.8	3.8	3.9

found that β-carotene was better retained in the jack fruit RTS samples packed in green colour bottles followed by colourless bottles. As the storage period increased, reduction in β-carotene content was observed in the RTS of both the varieties. β-carotene contents of the V_1 and V_2 samples in green colour bottles were 7.50-8.70 and 7.45-9.62 mg/100 ml respectively. Similar findings of decrease in β-carotene content in mango RTS beverage during storage was observed by Beerh et al (1989).

Statistical differences for the β-carotene content of RTS samples were noted between varieties and packaging materials throughout the storage period. The freshly prepared 'Vellipala' RTS had bright yellow colour and strong flavour than the RTS from 'Local' variety.

The packaging materials used for storing (packing) had influenced the changes in the colour of the RTS beverage. Slightly higher degradation of the original colour of the "Local" variety samples in colourless bottles was noted.

RTS beverages prepared from jack fruit were evaluated for their sensory quality attributes viz., appearance, colour, flavour and taste and the score values are presented in Table 2. A slight decrease in sensory scores for appearance, colour, flavour, taste and overall acceptability were observed during storage. The overall acceptability scores of RTS samples depend upon appearance, colour, flavour and taste. Jack fruit RTS beverages prepared from both 'Local' and 'Vellipala' varieties stored in green colour bottles were found to be satisfactory with respect to their sensory quality attributes upto six months. Between two varieties the RTS prepared from 'Vellipala' variety was found to be highly acceptable than the 'Local' variety.

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Drying Rates of Fully Exposed Peas

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A study was conducted to understand the drying behaviour of peas with high levels of moisture content. Three varieties of peas viz., 'Pb-87' 'Pb-88' and 'Matar Ageta-6' were dried in a series of drying experiments in thin-layer within the temperature and relative humidity range of 55 to 75°C and 24 to 40 %, respectively. Each sample was pre-treated before drying. The automatic weighing system was used to note the loss in weight of drying sample to minimize the errors, which otherwise would have been caused by interruptions. A drying air temperature of 60°C and drying time of 345 min were found to be most suitable for drying the variety 'Pb-87'. Thin-layer drying rates of peas were determined as a function of drying air temperature. The data were fit to several thin-layer drying models. The drying air temperature had a significant effect on drying rate. Page's equation with drying constants as a function of drying air temperature provided the best fit to the data.

Keywords : *Pisum sativum*, Thin layer drying, Pre-treatment, Drying constant, Half response time.

Pea (*Pisum sativum*) is a leguminous vegetable of immense importance consumed in several forms such as fresh green peas, dehydrated peas, processed canned peas and dehusked splits. It is a good source of essential nutrients. The area under cultivation of fresh peas in India was 6200 hectares with production of 561000 tonnes in 1995-96 (FAO1996). Fresh peas contain 233 % to 400 % (d.b) moisture and are extremely perishable. Dehydrated peas are gaining popularity because they offer the advantage of longer shelf life, palatability, convenience during transport and handling. Besides this, seasonal gluts of peas cause uneconomic returns to the growers, which can be overcome by dehydrating and using them during off season.

Numerous models have been proposed to describe the rate of moisture loss during thin layer drying of agricultural crops. As the shape of pea kernel is almost spherical, the drying theory available may be applicable to peas. Page (1949) developed a thin layer grain drying model of the form:

$$MR = \exp(-Kt^N) \quad \ldots. (1)$$

where, K and N = constants.

Thompson et al (1968) developed an empirical equation to describe thin layer drying data for shelled corn in the temperature range of 60 to 150°C.

$$t = A\ln(MR) + \beta \{\ln(MR)\}^2 \quad \ldots. 2$$

where, A and B = constants dependent upon drying air temperature. Pathak et al (1991) found the Page's equation could be successfully employed for the thin layer drying of rapeseed. Although a considerable amount of work has been reported in the literature on thin layer drying of agricultural products, no such information is available for peas. The objective of this study was to develop a thin layer drying model for pea kernels in the temperature range of 55 to 75°C. The effect of drying on physical properties like size and bulk density of peas was also studied.

The three different varieties of peas viz 'Pb-87', 'Pb-88' and 'Matar Ageta-6' grown in Punjab were selected for thin layer studies. The samples were pre-treated according to Khurdiya et al (1972). The shelled peas were graded and blanched by tying the sample in muslin cloth and dipping for 5 min in 5 % boiling salt solution (common salt) containing 0.15 % sodium bicarbonate and 0.10 % magnesium oxide. The blanched peas were again tied in muslin cloth and sulphited for 30 min in 0.5 % aqueous potassium metabisulphite solution. The water was drained out and 300 g sample was taken for conducting the drying experiment. An automatic weighing system developed by Pardeshi (1998) was used with an experimental drier for experimentation. The pre-treated samples of all the varieties were dried at different temperatures viz 55°C, 60°C, 65°C, 70°C and 75°C. The air velocity was fixed at 100 m/min for all the experiments as it does not have any significant effect in thin layer drying. The weights of the drying samples were taken at regular intervals. When the samples reached the constant weight, the peas were assumed to be at the equilibrium moisture content, for the test conditions. The data were statistically analysed.

The loss in weight of peas during drying run at different temperatures with time was transformed in to moisture contents (d.b.). The relationship between moisture content and drying time is shown for different varieties at different temperatures in Fig. 1-3. Initially moisture decreased rapidly and then slowed down. From the figures, it was observed that 80 % of moisture content was lost in first 60 to 105 min of drying for variety 'Pb-87', 'Pb-88' but was higher for 'Matar Ageta-6'. The total drying time required to reach a moisture content of 6 % (d.b.) was different for each variety and temperature. It is given in Table 1.

The statistical analysis showed that temperatures had a significant effect over drying time required. The increase in drying temperature from 55 to 75°C reduced the drying time by 30.14 %, 32.24 % and 36.16 % for varieties 'Pb-87', 'Pb-88' and 'Matar Ageta-6' respectively. The variety 'Pb-88' took more time to dry under all conditions. The data were analysed statistically to decide the best variety and temperature for drying purpose and it was found that the variety 'Pb-87' and the drying temperature of 60°C was best for drying purpose.

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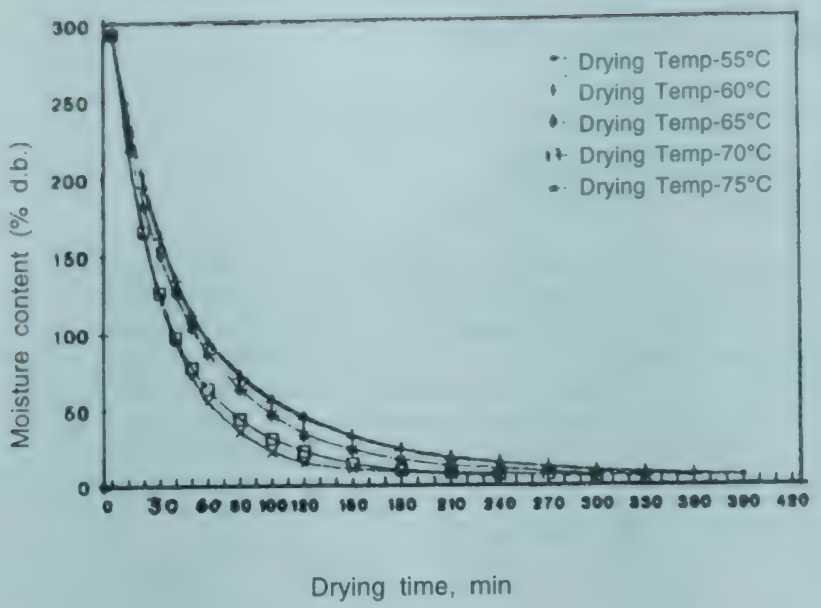

Fig. 1. Relation between moisture content and drying time for variety 'Pb-87'

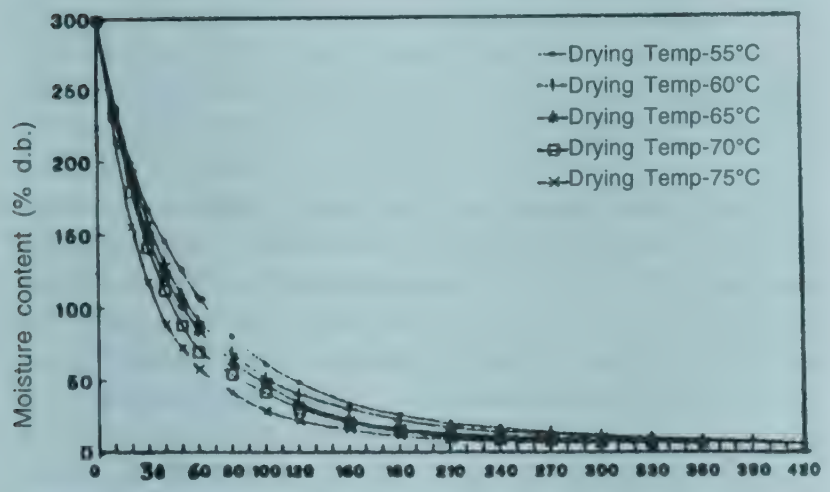

Fig. 2. Relation between moisture content and drying time for variety 'Pb-88'

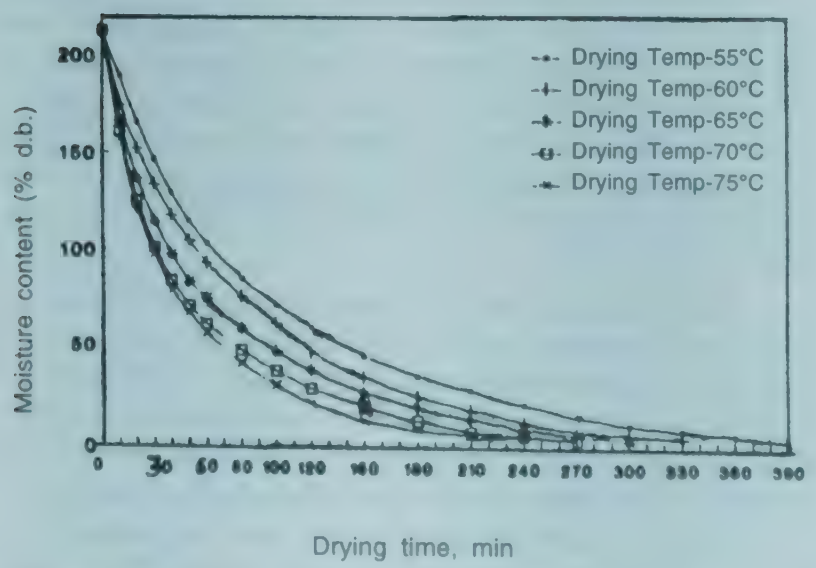

Fig. 3. Relation between moisture content and drying time for variety 'Matar ageta-6'

The moisture ratios were determined at all the drying times and it was found that the rate of moisture loss decreases as the elapsed time increases, until finally the peas approach the equilibrium moisture content (MR=0). The initial and equilibrium moisture contents of all the varieties have been given in Table 2. Equations (1) and (2) are proposed to describe this data. These equations were fitted to drying data. The drying constants K and N for equation (1), A and B for equation (2) alongwith the co-efficient of correlation (R^2) were determined for each drying run. Equation (1) describes the observed moisture content data better than the equation (2). So the Page's equation was found to be best suited for peas. The Page's equation was applied to the drying data of all the three varieties of peas but statistically it was found that there was non-significant difference in the drying constants of these varieties. Therefore, a single general equation is given for 'Pb-87' variety of peas of the form $MR=\exp(-Kt^N)$ with co-efficient of correlation 0.988. The values of K and N at all temperatures are given in Table 3. The diffusion co-efficients of peas were determined at different temperatures and the values are given in Table 3. There was not much difference in the diffusion co-efficient at temperatures of 55, 60 and 65°C. However, it has an increasing trend with increased drying air temperature. This may be due to reason that with increase in temperature, the drying time and equilibrium moisture content decreased. The size and bulk density of all the varieties of peas was determined before and after the drying. The results are given

TABLE 1. TOTAL DRYING TIME (MINUTES) FOR DIFFERENT VARIETIES

	Drying temperature, °C				
Variety	55	60	65	70	75
'Pb-87'	365	345	315	279	255
'Pb-88'	410	388	339	305	277
'Matar Ageta-6'	365	318	227	245	223

TABLE 2. INITIAL AND EQUILIBRIUM MOISTURE CONTENTS (% D.B.) FOR DIFFERENT VARIETIES AT DIFFERENT DRYING TEMPERATURES

	Initial moisture content	Equilibrium moisture content temperature, °C				
		55	60	65	70	75
'Pb-87'	293.7	3.87	2.94	2.02	1.89	1.22
'Pb-88'	298.4	3.63	2.99	2.41	1.92	1.33
'Matar Ageta-6'	212.5	2.09	1.84	1.44	1.42	0.97

TABLE 3. DRYING CONSTANTS TIME OF HALF RESPONSE AND DIFFUSION CO-EFFICIENTS OF PEAS AT DIFFERENT TEMPERATURES

Temp, °C	K, 1/min	N	Time of half response, min	Diffusion co-efficient, cm^2/s
55	0.2989	0.831	43.46	3×10^{-6}
60	0.03271	0.835	37.83	3.1×10^{6}
65	0.03688	0.841	32.71	3.2×10^{6}
70	0.041173	0.845	28.21	3.6×10^{6}
75	0.0451	0.849	24.90	3.75×10^{6}

in Table 4. The density and size of all the varieties of peas decreased with drying. The decrease in density results in higher porosity which is a desirable quality for rehydration and reconstruction of dried foods.

The perusal of Table 3 shows that as drying air temperature increased the value of drying constants increased. These constants were generalised as functions of drying air temperature. Several equations were tested in the regression

TABLE 4. EFFECT OF DRYING ON PHYSICAL PROPERTIES OF PEAS

Variety	Diamter, cm		Bulk density, g/cm³	
	Fresh	Dried	Fresh	Dried
'Pb-87'	0.81	0.67	0.61	0.54
'Pb-88'	0.89	0.70	0.58	0.52
'Matar Ageta-6'	0.97	0.72	0.60	0.54

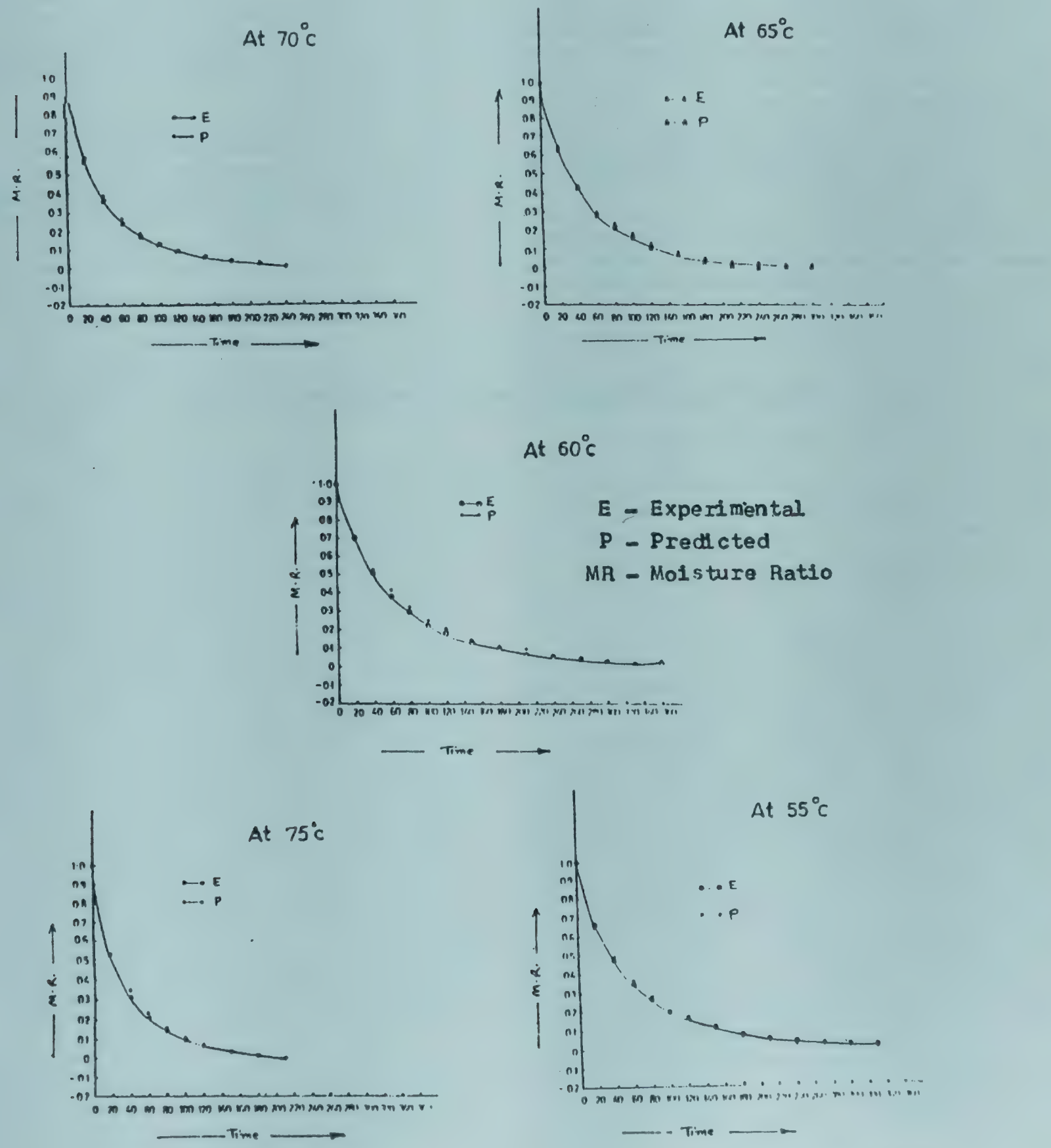

Fig. 4. Comparison between experimental and predicted (Page's eqn.) data of moisture ratio at any drying time for peas.

procedure to generalise these constants. The linear model was fitted best with the following equation:

$$K = 0.0007776 \quad T - 0.013394 \quad (R^2 = 0.998)$$

The drying constant N is also strongly correlated with the drying air temperature and yields the following equation:

$$N = 0.00092 \; T + 0.7804 \; (R^2 = 0.997)$$

where T = the drying air temperature °C

Moisture ratios predicted with the generalised model were compared with observed moisture ratios from the actual experiments at different drying air temperatures as shown in Fig. 4. These results demonstrate that the model tracks the observed moisture ratios well throughout the entire period of each run. The time of half response was calculated at all the drying air temperatures and is presented in Table 3 which shows that drying air temperature had an effect on the time of half response which was the time to reach the moisture ratio a value of 0.5. As the temperature increased the time of half response decreased.

Thus, it can be concluded that the time of half response had an effect in the beginning of the experimentation. The time required for variety 'Pb-87' at a drying air temperature of 60°C was 345 min. Page's equation with drying constants as a function of drying air temperature provided the best fit to the data. The data are useful in design and development of drier and improvement in processing technique.

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RESEARCH NOTE

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Microbiological Quality of Fish, Rohu Marketed in Patna and Its Public Health Significance

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A total of 80 samples, (40 gills and 40 intestines) from 40 rohu fishes were collected from different fish markets of Patna in sterilized plastic bags for isolation of aerobic bacteria. *E.coli, Pseudomonas* spp., *Staphylococcus* spp., *Klebsiella* spp. and *Proteus* spp. were isolated from samples. *Salmonella* was not found in any of the fish samples analysed. *Staphylococcus spp.* were found to be predominant both in gills and intestines, whereas *Klebsiella* spp. recorded lowest in these organs. The prevalence rates of these microorganisms among gills and intestines were found to be statistically significant ($P<0.05$). The public health significance of different members of aerobic bacteria isolated is discussed.

Keywords : Fish, Bacteria, Isolation, Gills, Intestine, Public health. Rohu, *Labea rohita.*

Generally, most of the vital organs of healthy and freshly caught fishes are bacteriologically sterile except the alimentary canal. However, it may get contaminated during harvesting, transportation and storage. The consumption of contaminated fish may cause various clinical disorders in human beings and has a great public health significance (Beri et al. 1989).

In addition to normal microflora, Rohu (*Labeo rohita*) may acquire additional microflora as contaminants during harvesting, handling, storage, transportation and marketing. The bacterial contamination of faecal origin may be contributed by water used for cleaning and sprinkling of fishes, hands of seller during handling and various instruments used during dressing of fishes.

The microbilogical analysis is important to generate data on changes during handling of equipment, transport of live fishes and cleaning, finally the extent of spoilage of fishes.

As no systematic microbiological studies have been carried out on the aerobic bacteria of fish marketed at Patna, the present investigation was undertaken to know the bacterial status of market fish of Patna.

Eighty samples, 40 gills and 40 intestines from 40 Rohu (*Labeo rohita*) fishes were collected at regular intervals from different fish markets of Patna. Two grams each of gill and intestine was first inoculated in a test tube containing nutrient broth separately and incubated at 37°C for 24 h. Sub-culture was done on blood agar, nutrient agar, Baired and Parker agar and MacConkey's agar plates. These were incubated at 37°C for 24 h. For isolation of *Salmonella,* one gram each of gill and intestine was inoculated in Kauffmann-Muller Tetrathionate broth tubes separately and incubated at 37°C for 18 h. Sub-culturing was made from these tubes on MacConkey's agar plates and Salmonella-Shigella agar plates and were incubated at 37°C for 24 h. After incubation, all these plates were examined for the growth of any bacterial colony. All the representative colonies were obtained in pure form by conventional method and were characterized as described by Cowan (1977).

The prevalence rates of aerobic bacterial isolates in gills and intestines have been presented in Table 1. It is evident from the table that out of 40 gills *E.coli, Pseudomonas aeruginosa, Staphylococcus aureus, Staphylococcus epidermidis, Klebsiella pneumoniae, Klebsiella aerogenes, Proteus mirabilis* and *Proteus vulgaris* were detected in percentages of 27.50, 30.00, 27.50, 35.00, 2.50, 17.50, 7.50 and 15.00 respectively. Intestinal samples also revealed *E.coli, Pseudomonas aeruginosa, Staphylococcus aureus, Staphylococcus epidermidis, Klebsiella pneumoniae, Klebsiella aerogenes, Proteus mirabilis* and *Proteus vulgaris* in percentages of 35.00, 27.50, 20.00, 30.00, 5.00, 17.50, 10.00 and 15.00 respectively. *Staphylococcus* spp. were found to be predominant both in gills and intestines, whereas *Klebsiella spp.* were recorded the lowest in these organs.

The overall prevalence rate of *E. coli* (31.25 %) (Table 1) in market fish of Patna is in close agreement with that reported by various workers (Ayulo et al. 1994, Sinha et al. 1991). However, as high as 40.00 % prevalence was reported by Stephen et al (1975). In the present study gills revealed an overall prevalence of *E.coli* as 27.50 %. Sinha et al (1991) also detected 33.33 % *E.coli* in gills of rohu fish marketed at Ranchi.

As gills of fish act as filtering membrane, bacterial flora of gills reflects the bacteriological status of water which may also be considered as an indicator of sanitary condition of water from where these were harvested (Wood 1953).

Besides, the exogenous contamination, *E.coli* is a normal intestinal flora and thus gains access to tissue due to agonal invasions during the terminal stage of life. *E. coli* besides being an important indicator, its various enteropathogenic strains are known to cause gastro-enteritis in children and adults with various clinical disorders (Beri et al 1989).

In the present study, coagulase-positive strains of *Staphylococcus* were isolated in percentages of 27.50 and 20.00 from gills and intestines respectively whereas coagulase-negative *Staphylococcus* were 35.00 % and 30.00 % from gills and intestines respectively (Table 1) confirming the isolation of *Staphylococcus* from fish by different workers (Ferrer et al 1992, Shimizu et al 1991, Sinha et al 1991). Many coagulase or thermonuclease positive strains of *Staphylococcus aureus* produce enterotoxin during growth, which can cause food poisoning and is considered to be of public health significance.

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TABLE 1. PREVALENCE OF AEROBIC BACTERIA IN MARKET FISH OF PATNA

Samples	No of samples examined	Number of organisms isolated								
		E.coli	*Pseudomonas aeruginosa*	*Staphylococcus aureus*	*Staphylococcus epidermidis*	*Klebsiella pneumoniae*	*Klebsiella aerogenes*	*Proteus mirabilis*	*Proteus vulgaris*	
Gills	40	11 (27.50)	12 (30.00)	11 (27.50)	14 (35.00)	1 (2.50)	7 17.50)	3 (7.50)	6 (15.00)	X^2 at 7df= 18.321*
Intestine	40	14 (35.00)	11 (27.50)	8 (20.00)	12 (30.00)	2 (5.00)	7 (17.50)	4 (10.00)	6 (15.00)	X^2 at 7df= 15.00*
Total	80	25 (31.25)	23 (28.75)	20 (25.00)	26 (32.50)	3 (7.50)	14 (35.00)	7 (17.50)	12 (30.00)	X^2 at 7df= 31.721**

Figures in parentheses indicate percentage

Overall prevalence rate (28.75 %) of *Pseudomonas aeruginosa* (Table 1) observed in the present investigation is in close agreement with the findings of AL-Shibib and AL-Musleh (1985) and Surendran and Gopakumar (1983). However, lowest prevalence rate (1.93 %) and highest prevalence (40.00 %) was reported by Levin (1963) and Okafor and Nzeako (1985), respectively.

Pseudomonas spp. is an opportunistic organism and has been found associated with human diarrhoea (Chatterjee and Neogy 1971) and an outbreak of gastroenteritis in children (Sharma et al. 1979) Besides causing disease, the presence of this organism in fish may result in great economic losses due to production of off-odour and off-flavours and finally spoilage of fishes (Castell and Greenough 1957, Surendran and Gopakumar 1983).

The presence of *Klebsiella* spp. in fish supports the findings of Singh and Kulshrestha (1984). *Klebsiella* spp. is a well known opportunistic pathogen and its role in food borne illness was reviewed by Wilson et al (1984). Wadstrom et al (1976) isolated enterotoxigenic strains of *Klebsiella* from clinical cases of diarrhoea and its enterotoxigenicity was also proved by Klipstein and Engert (1977).

Overall prevalence of *Proteus mirabilis* (17.50 %) and *Proteus vulgaris* (30.00 %) (Table 1) in the present study substantiates the findings of different workers (Okafor and Nzeako 1985, Sinha et al. 1991) and their presence may be of public health significance as the different species of *Proteus* are known to cause diarrhoea, dysentry and various other diseases in human beings.

The present findings suggest that the market fish of Patna is cotaminated with several pathogens which are generally associated with different clinical conditions of human beings. Though, absence of *Salmonella* is a good sign for consumers, the public health importance of the above findings cannot be ignored.

Therefore, it is stressed that strict hygienic measures should be adopted right from harvesting to bringing the cooked fishes at the dining table to safeguard the health of consumers.

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RESEARCH NOTE

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Pilot Scale Brewing Trials Using Formulated Blends of Selected Local Vegetables as Hop Substitute

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Suitability of two blends of Utazi (*Gongronema latifolium*), Bitter leaf (*Vernonia amygdalina*) and Bitter cola (*Garcinia kola*) in ratios 1:6:2.3 (THS 1) and 0:1:2 (THS 2) as replacements for commercial hops in sorghum lager brewing was investigated. Proportions of vegetables in both blends were obtained through linear programming. Both blends were analysed for fat, tannin, essential oil, total resin and alpha acid contents and then tested on pilot scale brewing trials alongside commercial hops that served as control. Beer samples produced were analysed for their chemical composition, colour, clarity, head foam (formation and retention), bitterness and flavour. The blends of vegetables tested had similar chemical composition and organoleptic properties as those of commercial hops, and offer replacement potentials for the latter in sorghum-based lager beer brewing. However, the use of the vegetable blends will require an efficient filtration system for production of beer of acceptable clarity.

Keywords : Beer brewing, Hop, Utazi, Bitter leaf, Bitter cola, Sorghum.

Hop, a brewing raw material, imparts desirable flavour, aroma, colour, bitterness and foam stability to beer in addition to conferring antiseptic properties to the product (Hough 1980). Unfortunately, commercial hops are produced from the flowers of the hop plant (*Humulus lupulus*), a temperate crop that cannot be successfully grown in tropical countries like Nigeria. Therefore, its import into Nigeria for beer brewing is imperative. The large sum of money spent on the import of hops by over thirty-three indigenous brewing industries in Nigeria (Federal Office of Statistics 1986; FAO Yearbook 1987; Corporate Directory 1990) and the attendant drain on foreign exchange, necessitate the search for cheaper and locally available alternative sources. Bittering and anti-microbial properties of neem (*Azagdiratha indica*), kola nut (*Kola nitida*), utazi (*Gongronema latifolium*), bitter cola (*Garcinia kola*) and bitter leaf (*Vernonia amygdalina*) were evaluated (Okafor and Anichie 1983; Eka 1984; Aina and Uko 1990; Okoro 1993). Although the authors suggested potential uses of these vegetables as hop substitutes in beer brewing, they concluded, however, that no single vegetable satisfactorily replaced commercial hop. There is a need, therefore, to examine possibility of replacement of commercial hop with a combination of vegetables. Indeed, hops of commerce are a blend of different varieties of hops (Hough 1980).

The prospects of replacing commercial hops with pelletised blends of utazi, bitter leaf and bitter cola in ratios established through linear programming are discussed in this communication.

Preparation of blends of hop substitutes : Freshly harvested matured and healthy utazi (*Gongronema latifolium*), bitter leaf (*Vernonia amygdalina*) and bitter cola (*Garcinia kola*) were washed with distilled water, drained and oven-dried at 80°C for 24 h in a draught air oven, until they were sufficiently crispy. The dried vegetables were milled using a Hammer mill (8,000 rpm; Chrystylab mill, model 8) with sieve size of 1.25 mm and then kept in airtight containers, until required for preparation of blends tested as hop substitutes. The milled samples of dried utazi, bitter leaf and bitter cola were mixed in the ratios of 1:6:2.3 and 0:1:2 to make two blends of vegetables THS 1 and THS 2, respectively. The blending ratios were obtained through linear programming as described by Okoro (1993). The resulting blends were pelleted by applying 2 metric tonnes pressure on 1g sample for 1 min using a Carver laboratory press (Model C, Ser. No. 3400-298; W 142 V9050 Fountain BLVD). The pellets produced were of 1.2 cm width and 0.6 cm thickness. The pellets were vacuum-packed in 0.15 mm thick polythene sachet using a domestic vacuum packaging unit (PIFCO) and stored in a cool dry place.

Brewing trials : Brewing trials were conducted at the Sona Breweries Plc, Sango Ota, Ogun State. Sorghum malt was prepared as described by Okon and Uwaifo (1985). Malting lasted a maximum of 5 days and the green malts were oven-dried at 50°C for 48 h to reduce moisture level from 45 % to about 8 %. Wort produced from malted sorghum was used in the conventional brewing procedure (Hough et al. 1982) employed in production of beer. In the control brewing trial (trial 1), commercial hop was used during the boiling operation, while THS 1 and THS 2 replaced commercial hop as substitutes in trials 2 and 3, respectively.

Analytical procedures and organoleptic evaluation : The alpha acid, essential oil, resin and tannin contents of the blends were determined using the Institute of Brewing (1985) method. The analytical bitterness, colour, haze, attenuation (real and apparent), real extract, alcohol and carbon dioxide contents of the beer produced from the three brewing trials were also determined as described by Institute of Brewing (1977). Foam head retention was determined using the method of Hough et al (1982).

A panel of five trained judges evaluated beer samples in terms of foam (formation and retention), colour, bitterness and flavour in a sensory evaluation using a 9-point Hedonic scale (Larmond 1977).

Statistical analysis of results : Results obtained in the study were subjected to statistical analysis as per the procedures of Steel and Torrie (1980).

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TABLE 1. COMPONENTS OF BREWING IN THE EXPERIMENTAL HOP SUBSTITUTES (BLENDS) AND COMMERCIAL HOPS

Constituents, %	Blend THS 1	THS 2	Commercial hops*
Alpha acid	8.27	7.93	11.00
Essential oil	1.46	1.25	0.50
Total resins	14.86	15.11	15.30
Fat	6.20	4.39	3.00
Tannin	3.42	3.58	4.00

Each value is mean of three replicates
+Source: Sona Breweries Plc, Sango-Ota, Ogun State (1999)

Alpha acid, essential oil, total resin, fats and tannin present in hops are responsible for the desirable physical quality attributes of beer (Okafor and Anichie 1983; Eka 1984; Aina and Uko 1990; Okoro 1993). Hence, they constituted the input variables in the linear programming employed for obtaining the proportions of each of the test vegetables in the two blends (THS 1 and THS 2) tested as hop substitutes in the brewing trials 1 and 2. Consequently, the resulting blends were analysed for the components and the results are shown in Table 1. Both blends showed similar composition excepting in case of fat, which was significantly higher in THS 1. Furthermore both blends compared with commercial hops (Sona Breweries Plc) in terms of their contents of total resins and tannins. On the other hand, because they were superior in their contents of essential oil, they had remarkably less amounts of alpha acid. However, they were found similar to Wye-Challenger, a brand of hop, in their alpha acid contents (Marr 1985).

In order to ascertain suitability of the two blends of the test vegetables as replacements for commercial hop used in the brewing industry, ingredient formulation for brewing of the brand of beer being produced by Sona Breweries Plc i.e. Gold larger beer was adopted. In addition, this consideration will lend the results to practical application. The commercial hop and the two blends of vegetables tested in the present study were used at the same rate (4.0 $g1^{-1}$). Results in Table 2 show that colour, haze formation, head foam retention, apparent and real degrees of attenuation and bitterness of the beer produced in the present study were markedly affected by the hop materials used. With the exception of apparent and real degrees of attenuation, significant effect of the hop material on the other quality attributes is in agreement with earlier reports (Hough et al. 1982).

Comparison of the affected quality parameters among the beer produced with the blends and the commercial hops indicated that replacement of commercial hop with THS 1 did not affect colour and foam head retention of the product. On the other hand, with THS 2 as replacement, intensity of colouration was reduced, whereas head foam retention increased significantly. The use of both blends resulted in significantly higher haze formation and degrees of attenuation (apparent and real), while bitterness was significantly reduced (Table 2).

Results of organoleptic assessments of beer brewed with the experimental hop substitutes and the commercial

TABLE 2. QUALITY ATTRIBUTES OF BEER BREWED WITH THE EXPERIMENTAL HOP SUBSTITUTES (BLENDS) AND COMMERCIAL HOPS*

Parameters	Blend brewed with THS 1	THS 2	Commercial hops	±SEM
Colour, EBC	15.00[a]	7.50[b]	16.00[a]	2.682
Haze formazin, EBC	1.10[a]	0.85[b]	0.65[c]	0.130
Foam head retention, sec	134.00[b]	140.00[a]	128.00[b]	3.464
pH	4.08	3.88	4.05	0.062
CO_2,g/l	4.80	5.10	5.70	0.265
Alcoholic content, w/w; %	4.76	3.50	3.83	0.377
Specific gravity (at 20°C)	1.00371	1.00659	1.00761	1.168E-3
Real extract, %	3.10	3.00	3.70	0.219
Refractive Index	35.00	31.30	35.80	1.386
Apparent degree of attenuation, %	92.28[a]	91.56[a]	82.51[b]	3.144
Real degree of attenuation %	74.80[a]	78.44[a]	66.82[b]	3.432
Apparent density ρ	1.95	1.95	1.95	0.333
Bitterness, EBU	23.00[b]	21.00[b]	27.00[a]	2.728

Each value is mean of three replicates
*Values in a row denoted by different superscripts are significantly different (p>0.05)

TABLE 3. MEAN SCORES OF ORGANOLEPTIC ASSESSMENTS OF BEER BREWED WITH THE EXPERIMENTAL HOP SUBSTITUTES (BLENDS) AND COMMERCIAL HOPS

Parameters assessed	Blend THS 1	THS 2	Commercial hops
Foam formation	8.4	8.5	8.5
Foam retention	7.8	8.0	8.0
Colour	8.0	8.0	8.5
Clarity	4.0[b]	7.0[a]	8.5[a]
Bitterness	6.1[b]	6.3[b]	8.2[a]
Flavour	7.2	7.5	7.9

Mean values in a row denoted by different superscripts are significantly different (p>0.05)

hops are shown in Table 3. The results showed that no remarkable difference was observed in the acceptance of beer brewed with the substitutes and the commercial hop in terms of foam formation and retention, colour and flavour. Bitterness was rated lower in THS 1 and THS 2 beer samples. Clarity was poor in case of THS 1 beer.

Bitterness in beer has been attributed to the total resin constituents (i.e. α-and β-acids) of the hop (Hough 1980). Since no marked difference was observed in total resin contents of THS 1, THS 2 and commercial hops tested (Table 1), significant differences that were observed in the degree of bitterness of beer samples (Tables 2 and 3) were unexpected. The remarkable reduction of bitterness of beer due to the use of both blends of vegetables might have been due to their significantly lower α-acid contents. The results of present study tended to confirm earlier reports that the α-acids, is a major determinant of the source of the bitter character (Iso-alpha acids, produced during wort boiling by a benzilic or

acyloin rearrangement) of beer brewed with fresh hops (Verzele 1979; Benton 1984).

The non-significantly lower tannin contents of the two blends tested (Table 1) seemed to suggest that significantly higher haze formation (Table 2) and poorer clarity of beer sample brewed with THS 1 (Table 3) was not due to tannin. Rather, it might be due to other sources as suggested by Moll (1987) and that the filtration system in use at Sona Breweries Plc for clarification of wort produced with the commercial hop tested was inefficient for wort produced with THS 1 and THS 2. Haze formation results from insoluble compounds produced through reaction and cross-linking of tannins with protein molecules during mashing (Daiber 1975; Doherty et al. 1987). In addition, hydrolysis of starches and proteins are retarded and consequently, the wort derived will contain partly hydrolysed substances, which give viscous wort and slow down wort and beer filtration (Aisen and Muts 1987). With an inefficient filtration process, haze develops. Haze in beer may also be due to the presence of inorganic elements, organic elements (especially oxalates), phenolic and polyphenolic substances (Moll 1987).

Degree of attenuation is an indication of how readily hydrolysable is the starch base and consequently, relative availability of fermentable sugars (Ugboaja et al. 1991). Higher degree of attenuation was obtained for beer brewed with THS 1 and THS 2 that had lower contents of tannin (Table 1), which might have been due to less amount of sorghum starch reacting with tannin. Since malted sorghum was the starch base for beer produced with both blends and commercial hop, its relative availability will be a function of the extent to which the starch complexes with tannin and consequently the retardation and/or prevention of its hydrolysis (Daiber 1975; Doherty et al. 1987).

Higher foam head retention was observed in beer brewed with the blends of vegetables as hop materials, their significantly higher fat contents (Table 1) not withstanding. This seemed to suggest that the beer samples had capacities to foam adequately. Furthermore, the addition of foam stabiliser (Biofoam) in the ingredient formulation at the level of inclusion for beer brewing at Sona Breweries Plc was sufficient to maintain satisfactory foam head retention of beer brewed with test blends. Foaming behaviour in beer is due mainly to amount of beer proteins, the major foaming agents, and their interaction with lipids, metal ions and charged polysaccharides (Ugboaja et al. 1991). The interaction of fats with foaming principles leads to collapse of foam bubbles.

Conclusion

From the results, it may be concluded that blends of Utazi, Bitter leaf and Bitter cola in ratios established through linear programming i.e. 1:6:2.3 and 0:1:2 possess characteristics similar to those of and they offer remarkable replacement potentials for commercial hops in sorghum-based larger beer brewing. However, the use of the vegetbale blends will require an efficient filtration system for production of beer of accetable clarity.

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RESEARCH NOTE

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Composition and Food Value of Sclerotium (*Osu*) and Edible Mushroom *(Pleurotus tuber-regium)*

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The composition and food value of edible mushroom (*Pleurotus tuber-regium*) and the sclerotium or tuber (*osu*) from which the mushroom was grown showed that the latter (sclerotium) was a richer source of most of the food nutrients assessed than the former (mushroom). The sclerotium was found to be a rich source of proteins, fat, crude fibre, minerals and carbohydrates. When compared with some of the other important food materials widely consumed in Nigeria, such as root tubers (cassava and yam) or cereals (maize, sorghum and rice), the mushrrom (*P. tuber-regium*) and the tuber (sclerotium) contained a wider range of food nutrients than those of the root tuber and cereal, indicating that *P. tuber-regium* and the sclerotium had a more balanced food value. The fungus could, therefore, be a cheap source of proteins for many Nigerians who may not afford proteins in their diets from the more commonly known but expensive sources of proteins such as beef or eggs.

Keywords : Sclerotium, *Pleurotus tuber-regium*, Composition, Food value.

Pleurotus tuber-regium is a *basidiomycete* found in the tropical and sub-tropical regions of the world (Zoberi 1972, 1973). The fungus is prevalent in Nigeria, and each tribe has recognised it for many years (Oso 1977). This organism is of immense economic value since both sclerotium and mushrrom grown from it are edible. The sclerotium known as "osu" in the Igbo-speaking areas of South-eastern part of Nigeria is used as a condiment for making soup. It is also used in the preparation of some peppery snacks that facilitate drinking of palm wine, especially on festive occasions. This apart, various traditional medicinal application of the sclerotium in different parts of Nigeria has been reported (Oso 1977). Notable among these are its application for the treatment of boils, constipation and in dental problems.

Again, the presence of proteolytic enzymes in both the mushroom and the sclerotium has also been reported (Ude 1990; Okaka and Ude 1993). Available literature reveals that a number of investigations have been conducted on this organism. Oso (1977) reported the various physiological conditions necessary for the propagation of the organism. Okhuoya and Etugo (1993) studied the cultivation aspects of *Pleurotus tuber-regium.* Although both the mushroom and sclerotium are consumed in Nigeria, there is paucity of information on their food value. In this study, the proximate composition of sclerotium (*osu*) and mushroom of *Pl. tuber-regium* was determined and the data were compared with those of other important staple food materials widely consumed in Nigeria.

Samples of sclerotium and mushroom : Fresh samples of sclerotia (*osu*), which measured approximately 14 to 16 cm in diameter, were bought from a local market in Enugu, Nigeria. One of the sclerotia was cultivated in humus soil in a plastic bowl and watered twice daily for 13 days until the primodia developed into fully-grown mushrooms. The mushrooms were harvested and used along with the uncultivated sclerotium for comparative analysis.

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Moisture determination : The standard method of moisture determination in a thermostatically controlled oven at 105°C was used (Pearson 1976). During the course of drying the samples at 105°C, they were weighed at 30 min interval, till the samples attained a constant weight.

Total ash detetermination : Samples (0.5 g each) were weighed into dry platinum dishes of known weight. The dishes and contents were heated on a hot plate to gradually burn off carbonaceous residues after which the sample was ashed in a muffle furnace at 600°C for 1h. The dishes and contents were allowed to cool in a desiccator, after which the ash content was calculated.

Acid-insoluble ash determination : The ash obtained from above was boiled with 25 ml of 10 % (w/w) HCl for 5 min. The liquid was filtered through ashless filter paper and washed thoroughly with hot water. The filter paper was then ignited in the original dish (known weight), cooled and weighed. The acid-insoluble ash was recorded as the weight after ignition.

Fat and protein determination : The fat content was determined after extraction using the Soxhlet apparatus (Pearson 1976). Ground sample (1.0 g) was wrapped in a filter paper and placed into the Soxhlet extractor. Petroleum ether was used as the solvent to extract fat and the process was continued for 8 h. Following the recovery of the solvent after extraction, the fat content was determined. Protein estimation was by Kjeldahl method as described by Pearson (1976). The crude protein value was calculated from the N value using the factor 6.25.

Crude fibre determination : The method described by Pearson (1976) was employed for this determination. Briefly, 1.0 g of sample was extracted with light petroleum in an extraction apparatus. The de-fatted sample was air-dried and transferred into a conical flask. Exactly 200 ml of 0.25 N H_2SO_4 was added and boiled gently for 30 min. After boiling, the solution was filtered and the insoluble material was washed with boiling water to free the sample of acid. The sample was

TABLE 1. PERCENTAGE COMPOSITION OF *OSU* AND MUSHROOM

Parameters	*Osu*	Mushroom
Moisture	14.9 ± 0.32	87.9 ± 0.08
Total ash	0.6 ± 0.02	2.1 ± 0.07
Fat	3.0 ± 0.14	2.2 ± 0.25
Proteins	9.2 ± 0.17	3.1 ± 0.08
Acid-soluble ash	0.3 ± 0.02	0.8 ± 0.02
Crude fibre	13.1 ± 0.03	3.3 ± 0.04
Sodium	0.6 ± 0.02	0.1 ± 0.01
Potassium	0.5 ± 0.04	0.5 ± 0.02
Carbohydrates	57.8 ± 0.19	0.0

then transferred into the flask and 100 ml of 0.3 N NaOH was added and boiled for another 30 min. The sample was filtered through ashless filter paper and then washed thoroughly with boiling water. The insoluble matter was dried to a constant weight at 100°C, incinerated in a muffle furnace at 600°C and the crude fibre was then calculated.

Sodium and potassium determination : These were determined by flame photometry. Exactly 0.5 g of sample was transferred into the Kjeldahl digestion flask, followed by 7.0 ml of concentrated HNO_3, 1.0 ml of perchloric acid and 1.0 ml of H_2SO_4. The mixture was heated for 1 h and the colourless solution obtained was made up to 100 ml with distilled water. The flame photometer was set up and serial dilutions of standard sodium and potassium solutions were sprayed into the flame photometer and their emission intensities recorded. The sodium and potassium contents were extrapolated from standard curves of emission intensity versus sodium and potassium, respectively.

Carbohydrate determination : Carbohydrate content was obtained by difference as reported elsewhere (Ihekoronye and Ngoddy 1985) as follows :

Carbohydrate = 100-(crude protein + moisture+fat+total ash).

In genral, the results obtained in this study were expressed as mean ± SD. Results were subjected to statistical test of significant difference in mean using the Student's t-test.

The results in Table 1 clearly show that the sclerotium (*osu*) is a richer source of most of the food nutrients investigated than the mushrooms (*P. tuber-regium*). The lower value of moisture content of the sclerotium, in contrast to that of the mushrooms, was probably because the mushrooms were grown under high moisture conditions. But the lower value of acid-insoluble ash or the total ash of the sclerotium is difficult to explain. However, the higher percentage of moisture and the lower levels of the other nutrients obtained for the mushrooms were characteristic of mushrooms and confirmed the general opinion that mushrooms consisted almost entirely of water, with small amounts of proteins, fat, and carbohydrates (Henry 1993). The mushroom of *tuber-regium* had a total ash of 2.08 ± 0.07 %. Statistical analyses revealed significant differences ($P<0.001$) in the percentage composition of mushrooms and *osu* in respect of moisture, total ash, proteins, acid-insoluble ash, crude fibre, sodium and carbohydrates. There were, however, no significant differences in the values of fat and potassium. Mushrooms are known to have higher mineral content than beef and other vegetables (Genders 1990). It is clear from the results that the consumption of both *osu* and the mushroom could offer important alternative sources of food.

This study further revealed that both sclerotium and mushroom had higher contents of proteins when compared with some fruits like banana and orange (Table 2), and could be better alternative source of proteins. This is important because fruits are expensive and most people cannot afford to include them in their diets. It is also important to note that both sclerotium and mushroom compared well with tubers (cassava and yam) or cereals (maize, sorghum and rice) with regard to their protein content. Furthermore, the use of sclerotium as a soup thickener will provide additional cheap source of protein for the teaming population of Nigeria who may not afford the use of beef as protein source because beef is very expensive. The fat contents of sclerotium and the mushroom are very similar to those of the popular cereals, but the higher crude fibre of sclerotium and the mushroom makes this fungi an extremely good source of roughage in the diet of Nigerians. Fibre plays an important role in our diet, as it promotes the bowel movement at ease in order that the faecal matter is excreted from the body (Okaka et. al. 1992). Traces of sodium and potassium present in both sclerotium and the mushroom will contribute to a better functioning of the activities of the cell, as these minerals are required for the normal physiological functioning of the cells.

TABLE 2. PERCENTAGE COMPOSITION OF *OSU,* MUSHROOM AND OTHER FOOD SOURCES[++]

	Maize	Sorghum	Rice	Cassava	Yam	Bitter leaf	Okro	Banana[+]	Orange[+]	Mushroom	*Osu*
Moisture	~12	~12	~11	~80	~84	~83	~89	-	-	~88	14.9
Total ash	3	2	0.5	1.5	~5.5	-	-	-	-	2.1	0.6
Fat	3-5	3	2	0.1	~1.3	0.4	0.2	-	-	2.2	3.0
Proteins	~10	~10	~8	2-3	~6	5.3	2.1	0.8	0.6	3.1	9.2
AIA*	-	-	-	-	-	-	-	-	-	0.8	0.3
Crude fibre	2-3	2	2	1	~5.5	-	-	-	-	3.3	13.1
Sodium	-	-	-	-	-	-	-	-	-	0.1	0.6
Potassium	-	-	-	-	-	-	-	-	-	0.5	0.5
CHO**	~72	~72	~73	~30	~81	-	-	~14	~9	-	-58

[+]Source; Genders (1990); [++]Source Ihekoronye and Ngoddy (1985); *AIA=Acid insoluble ash; **CHO = Carbohydrate

Conclusion

The tuber (*osu*) and mushroom of *tuber-regium* can be considered as important food sources with a wide range of advantages since they contain various nutrients, such as proteins, carbohydrates and minerals which are the nutritional requirements of the body. They are also cheap and easily affordable as compared to the animal sources of proteins such as beef and eggs which are quite expensive and out of reach of most of the Nigerian populace. The various tribes in Nigeria have however, unknowingly recognised the importance of this fungus by including it in their diets and using it as medicine in diseases without realising its potential. The results reported in this communication have thrown some light into the nutritional aspects of *osu* and mushroom, which should play a vital role in the dietary of the local population.

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RESEARCH NOTE

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Application of Mixtures Methodology for Beverages from Mixed Fruit Juice/Pulp

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An experiment was conducted to study the feasibility of blending of fruit juice/pulp of lime, *aonla,* grape, pineapple and mango in different proportions (5 to 95 %) for preparation and standardization of ready to serve (RTS) beverages. The prepared RTS beverages were organoleptically evaluated adopting 9 point Hedonic scale. Among the different recipes tried for RTS beverages, LA-95 (lime 95 % + *Aonla* 5 %) recipe was found to be the best based on overall sensory score. The data generated were also analyzed in three different age groups (22-34 years, 35-44 years and 45-55 years) and response surface model was used to observe the variation in the liking of these beverages. The younger respondents (22-34 years) liked mango-pineapple and grape-pineapple blends, while the senior respondents (45-55 years) liked lime-*aonla* and mango-grape blends. It was found that the scores for overall sensory quality were higher for the mango-pineapple and grape-pineapple blends and lower for lime-*aonla* and mango-grape blends. The model developed through this study might help in future for predicting the economically feasible blending ratio of fruit juices/pulp for the beverages on a commercial scale.

Keywords : RTS beverages, Blends, Recipe, Sensory quality, Response surface model, Age group.

Fruits are highly perishable in nature and require immediate processing. The fruits like mango, pineapple, grape, lime and *aonla* are some of the fruits, which are grown in our country. Due to high acidity, astringency, and other factors in some of the fruits, the utilization of these fruits for preparation of various processed products are limited. Therefore, blending of two or more fruit juices for the preparation of Ready to serve (RTS) beverages is thought to be a convenient alternative for utilization of these fruits. Various workers (Sandhu and Sindhu 1992; Saxena et al. 1996; Attri et al. 1998; Langthasa 1999) have reported that two or more fruit juices/pulp may be blended in various proportions for the preparation of nectar, RTS beverages etc. The blending of juices may also improve aroma, taste and nutrients of the beverages. Finally, one could think of a new product development through blending in the form of a natural health drink which would also serve as appetizer.

The usual analysis of the data generated through sensory evaluation like one way classified ANOVA can identify the best combination among the combinations tried only. But, in this type of experiments, a mathematical relationship between sensory characteristics and mixture proportions can also be established using linear and quadratic canonical polynomials of Scheffe (1958, 1963), as the difference in characteristics of the beverages are only due to differences in the proportions of the ingredients. Such analysis would also help in predicting the characteristics of the beverages for the mixture proportions that were not tried during the experimentation. In some situations, these analysis also help in obtaining the optimum combinations.

Keeping these points in view, a research study was carried out during 1998-99 in the Post-harvest Technology unit of the Division of Fruits and Horticultural Technology, IARI, New Delhi to standardize the recipe(s) for the preparation of RTS beverages from mixed fruit juices/pulp.

The fruits of 'Dashehari' variety of mango, 'Desi' variety of *aonla,* 'Kagzi lime' and 'Kew' variety of pineapple were purchased from Azadpur Mandi, Delhi. 'Pusa Navrang' variety of grape (coloured) was collected from the orchard of the Division of Fruits and Horticultural Technology during 1998 and 1999.

Extraction of juice/pulp and their processing was done as per the standard procedures (Deka 2000). Juice/pulp of mango, pineapple, *aonla,* lime and grape was blended in different ratios (0:100, 5:95, 10:90, 15:85, 20:80, 25:75, 50:50, 100:0, 95:5, 90:10, 85:15, 80:20 and 75:25). The blended juices/pulp (lime-*aonla,* mango-pineapple, grape-mango and grape-pineapple) were used for the preparation of RTS beverages having 15 % juice/pulp, 10 °Brix and 0.2 % acidity except in lime-*aonla* beverages, which contained 6 % juice, 10 °Brix and 0.3 % acidity. The prepared beverages were organoleptically evaluated by a panel of 9 members adopting a 9 point Hedonic scale (Amerine et al. 1965).

Since, there had been wide differences in the ages of the panel members (respondents), it was felt that the ages of the respondents may have some effect on the characters of the beverages prepared from different fruit juice/pulp blends. Therefore, the data generated were divided into three groups based on the ages of the respondents. Considering the ages of the respondents as one of the factors and treatments (blended beverages) as another factor, the data were analyzed using two way classified, fixed effects, additive, homosedastic linear model using PROC GLM of SAS (Statistical Analysis Systems). This analysis helped only in identifying the best proportion/blend among the blends tried in the experiment. But, it may so happen that the best blend may be other than

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the blends tried. Such blends can be obtained if one can establish a mathematical relationship between the characteristics of the beverages and the mixture proportions in these experiments. Since the difference in characteristics of the beverages prepared was only due to the differences in the proportion of ingredients, the data generated were also analyzed using experiments with mixtures methodology (Scheffe 1958). The purpose of such analysis was to model the blending surface with the form of mathematical equations, so that

(i) Prediction of response from any mixture or combination of ingredients could be made empirically and (ii) Some measure of influence on the response of each component singly or in combinations with other components could be obtained.

The data generated were also analyzed by fitting quadratic canonical polynomial of Scheffe (1958, 1963). Linear and quadratic polynomials for two component systems were

$$Y_u = \beta_1 X_{1u} + \beta_1 X_{2u} + \beta_{12} X_{1u} X_{2u} + e_u \quad .....(1)$$

where Y = the response to the vth treatment combination (u=1, ...n), e_u = the error component assumed to be distributed normally with zero mean and constant variance.

β_1 represented the expected response to the mixture (I = 1,2)

β_{12} represented the deviation of the (ii) surface from planer surface (i)

$\beta_{12} > 0$ exhibited synergistic behaviour

$\beta_{12} < 0$ exhibited antagonistic behaviour

The equation (1) was fitted using the method of least squares. For more details, one may refer Cornell (1981) and Marquardt and Snee (1974). As $X_1 + X_2 = 1$, by substituting $X_2 = 1 - X_1$ in (i) we got

$$Y = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_1^2 + e_u \quad ..... (2)$$

where, $\alpha_0 = \beta_2$, $\alpha_1 = \beta_1 - \beta_2 + \beta_{12}$, $\alpha_2 = -\beta_{12}$

Using (2) it could easily be seen that for β_{12} and $\beta_1 - \beta_2 + \beta_{12} > 0$, the optimum combination (maximum favoured) was when

$$X_1 = -\frac{\alpha_0}{2\alpha_2} \text{ and } X_2 = 1 - X_1 \quad ..... (3)$$

However, if β_{12} = negative, then X_1 = the minimum value.

The experiment with mixtures methodology was used over all the thirteen treatment combinations ignoring the age effect. The experiments with mixtures methodology was also used for age groupwise as it helped in establishing separate relationship for different age groups which might be exploited by the food processing industries for targeting different age groups. The whole analysis was done using PROC REG of SAS (Little et al. 1991).

Fifty two different RTS beverages, 13 from each group, were prepared from 4 groups of blended fruit juices/pulp (lime-*aonla*, mango-pineapple, grape-pineapple and mango-grape). LA-95 (lime 95 % + *aonla* 5 %) was the best RTS beverage among all the beverages with respect to sensory evaluation study, which scored 7.82 out of 9.00. It was, however, evident that with the increase of *aonla* juice percentage, there was gradual decrease in the overall score of the beverage. This decrease in overall score might be due to astringency in the

TABLE 1. SENSORY EVALUATION OF LIME-*AONLA* BLENDED BEVERAGES THROUGH RESPONSE SURFACE MODEL

Response surface model				
Character	Model	R^2	F	RMSE
Colour	$Y = 7.50^*X_1 + 6.87^*X_2 + 1.13^*X_1X_2$	0.662	9.78**	0.204
Aroma	$Y = 7.59^*X_1 + 6.20^*X_2 - 1.55X_1X_2$	0.405	3.39	0.729
Taste	$Y = 7.41^*X_1 + 6.26^*X_2 - 1.60X_1X_2$	0.328	2.44	0.720
Overall	$Y = 7.50^*X_1 + 6.44^*X_2 - 0.669X_1X_2$	0.427	3.73	0.522
Age 1 (22-34 Years)				
Colour	$Y = 7.67^*X_1 + 6.60^*X_2 + 1.37X_1X_2$	0.553	6.18*	0.418
Aroma	$Y = 7.68^*X_1 + 6.30^*X_2 - 0.438X_1X_2$	0.464	4.33*	0.626
Taste	$Y = 7.61^*X_1 + 6.12^*X_2 - 1.87X_1X_2$	0.627	8.38*	0.498
Overall	$Y = 7.67^*X_1 + 6.35^*X_2 - 0.312X_1X_2$	0.678	10.50*	0.386
Age 2 (35-44 Years)				
Colour	$Y = 7.02^*X_1 + 6.63^*X_2 + 2.20X_1X_2$	0.254	1.700	0.425
Aroma	$Y = 7.13^*X_1 + 6.62^*X_2 - 3.65X_1X_2$	0.099	0.551*	1.130
Taste	$Y = 6.95^*X_1 + 7.15^*X_2 - 4.16X_1X_2$	0.091	0.550*	1.080
Overall	$Y = 6.93^*X_1 + 6.80^*X_2 - 1.73X_1X_2$	0.032	0.165	0.854
Age 3 (45-55 Years)				
Colour	$Y = 7.82^*X_1 + 7.36^*X_2 - 0.189X_1X_2$	0.378	3.040	0.248
Aroma	$Y = 7.95^*X_1 + 5.67^*X_2 - 0.546X_1X_2$	0.767	16.46**	0.529
Taste	$Y = 7.68^*X_1 + 5.51^*X_2 + 1.230X_1X_2$	0.648	9.19**	0.678
Overall	$Y = 7.84^*X_1 + 6.41^*X_2 + 0.765X_1X_2$	0.713	12.39**	0.386

*Significant at 5 % level; ** significant at 1 % level; RMSE = Root mean square error; R^2 = SSR/SST; SSR = Corrected sum of squares due to regression; SST= Corrected total sum of squares.

TABLE 2. SENSORY EVALUATION OF MANGO-PINEAPPLE BLENDED BEVERAGES THROUGH RESPONSE SURFACE MODEL

Response surface model				
Character	Model	R^2	F	RMSE
Colour	$Y = 6.06^*X_1 + 7.07^*X_2 + 2.74X_1X_2$	0.639	8.84**	0.364
Aroma	$Y = 5.84^*X_1 + 6.37^*X_2 + 0.749X_1X_2$	0.511	5.23*	0.226
Taste	$Y = 5.90^*X_1 + 6.52^*X_2 - 0.332X_1X_2$	0.402	3.36	0.320
Overall	$Y = 5.93^*X_1 + 6.65^*X_2 + 1.05X_1X_2$	0.570	6.65*	0.274
Age 1 (22-34 Years)				
Colour	$Y = 6.53^*X_1 + 7.20^*X_2 + 2.65X_1X_2$	0.274	1.64	0.631
Aroma	$Y = 5.98^*X_1 + 6.79^*X_2 + 0.906X_1X_2$	0.438	3.90	0.396
Taste	$Y = 5.99^*X_1 + 7.03^*X_2 + 0.280X_1X_2$	0.469	4.43*	0.467
Overall	$Y = 5.96^*X_1 + 6.97^*X_2 + 1.92X_1X_2$	0.607	7.74**	0.366
Age 2 (35-44 Years)				
Colour	$Y = 5.99^*X_1 + 7.09^*X_2 + 0.371X_1X_2$	0.457	4.210*	0.503
Aroma	$Y = 6.11^*X_1 + 6.11^*X_2 + 0.651X_1X_2$	0.011	0.054	0.531
Taste	$Y = 6.13^*X_1 + 6.17^*X_2 - 0.175X_1X_2$	0.002	0.009	0.509
Overall	$Y = 6.09^*X_1 + 6.42^*X_2 + 0.634X_1X_2$	0.094	0.521*	0.462
Age 3 (45-55 Years)				
Colour	$Y = 5.59^*X_1 + 7.23^*X_2 + 2.32X_1X_2$	0.503	5.06*	0.712
Aroma	$Y = 5.38^*X_1 + 6.39^*X_2 - 1.00X_1X_2$	0.524	5.50*	0.411
Taste	$Y = 5.54^*X_1 + 6.50^*X_2 - 2.53X_1X_2$	0.613	7.91**	0.361
Overall	$Y = 5.46^*X_1 + 6.69^*X_2 - 0.255X_1X_2$	0.557	6.28*	0.461

Explanation as under Table 1

beverages because of higher concentration of *aonla* juice. Among different groups like grape-mango, mango-pineapple and grape-pineapple GP-85 (grape 85 % + pineapple 15 %), MP-85 (mango 85 % + pineapple 15 %) and GM-95 (grape 95 % + mango 5 %) were best beverages with overall sensory score of 7.01, 6.93 and 6.82, respectively. Earlier, Saxena et al (1996) recorded highest score (7.6) in grape : mango (75:25) and grape:pineapple (50:50) RTS beverages. In the present study, grape:mango (75:25) scored 6.45 and grape:pineapple (50:50) scored 6.18 out of nine. This variation might be due to varietal difference and variability of the panel members.

The results obtained through the Scheffe's canonical polynomials revealed that the coefficent of X_1X_2 in lime-*aonla* (Table 1) in mango-pineapple (Table 2) and grape-pineapple (Table 3) blends was positive and mango-grape (Table 4) blends the coefficient of X_1 X_2 was negative in respect of overall quality. However, the coefficient of X_1X_2 was nonsignificant in all the blends except in mango-grape blends. The positive sign indicated that the blending proportions were

TABLE 3. SENSORY EVALUATION OF GRAPE-PINEAPPLE BLENDED BEVERAGES THROUGH RESPONSE SURFACE MODEL

Response surface model				
Character	Model	R^2	F	RMSE
Colour	$Y = 7.18^*X_1 + 6.09^*X_2 + 1.13X_1X_2$	0.567	6.540*	0.410
Aroma	$Y = 6.10^*X_1 + 6.08^*X_2 + 0.940X_1X_2$	0.057	0.305	0.323
Taste	$Y = 6.63^*X_1 + 6.07^*X_2 - 0.488X_1X_2$	0.379	3.060	0.304
Overall	$Y = 6.64^*X_1 + 6.08^*X_2 + 0.540X_1X_2$	0.425	3.690	0.278
Age 1 (22-34 Years)				
Colour	$Y = 6.86^*X_1 + 6.16^*X_2 + 4.68^*X_1X_2$	0.450	4.09	0.543
Aroma	$Y = 5.49^*X_1 + 5.93^*X_2 + 6.95^*X_1X_2$	0.673	10.29**	0.424
Taste	$Y = 6.56^*X_1 + 6.25^*X_2 + 2.86^*X_1X_2$	0.321	2.36	0.396
Overall	$Y = 6.31^*X_1 + 6.11^*X_2 + 4.83^*X_1X_2$	0.579	6.89*	0.351
Age 2 (35-44 Years)				
Colour	$Y = 7.58^*X_1 + 6.40^*X_2 - 1.38X_1X_2$	0.509	5.20*	0.503
Aroma	$Y = 6.13^*X_1 + 6.63^*X_2 - 3.33X_1X_2$	0.259	1.74	0.590
Taste	$Y = 6.21^*X_1 + 6.41^*X_2 - 3.63X_1X_2$	0.444	3.96	0.353
Overall	$Y = 6.56^*X_1 + 6.53^*X_2 - 1.95X_1X_2$	0.169	1.02	0.361
Age 3 (45-55 Years)				
Colour	$Y = 7.09^*X_1 + 5.72^*X_2 + 0.093X_1X_2$	0.553	6.17*	0.522
Aroma	$Y = 6.69^*X_1 + 5.68^*X_2 - 0.811X_1X_2$	0.416	3.55	0.510
Taste	$Y = 7.11^*X_1 + 5.55^*X_2 - 0.686X_1X_2$	0.696	11.43**	0.436
Overall	$Y = 6.91^*X_1 + 5.65^*X_2 - 0.357X_1X_2$	0.610	7.83**	0.425

Explanation as under Table 1

TABLE 4. SENSORY EVALUATION OF MANGO-GRAPE BLENDED BEVERAGES THROUGH RESPONSE SURFACE MODEL

Response surface model				
Character	Model	R^2	F	RMSE
Colour	$Y = 7.14^*X_1 + 7.05^*X_2 + 2.38X_1X_2$	0.265	1.81	0.336
Aroma	$Y = 6.69^*X_1 + 6.44^*X_2 - 02.25^*X_1X_2$	0.463	0.43*	0.231
Taste	$Y = 6.68^*X_1 + 6.60^*X_2 - 2.14X_1X_2$	0.320	2.36	0.265
Overall	$Y = 6.84^*X_1 + 6.70^*X_2 - 2.27^*X_1X_2$	0.528	5.59*	0.188
Age 1 (22-34 Years)				
Colour	$Y = 7.33^*X_1 + 7.19^*X_2 - 2.79X_1X_2$	0.214	1.36	0.462
Aroma	$Y = 6.89^*X_1 + 6.61^*X_2 - 3.39X_1X_2$	0.238	1.56	0.549
Taste	$Y = 6.95^*X_1 + 6.54^*X_2 - 2.97X_1X_2$	0.324	2.39	0.437
Overall	$Y = 7.05^*X_1 + 6.78^*X_2 - 3.07X_1X_2$	0.351	2.70	0.382
Age 2 (35-44 Years)				
Colour	$Y = 6.84^*X_1 + 6.64^*X_2 - 2.24X_1X_2$	0.140	0.814*	0.511
Aroma	$Y = 6.77^*X_1 + 6.33^*X_2 - 3.59X_1X_2$	0.158	0.939*	0.814
Taste	$Y = 6.91^*X_1 + 6.64^*X_2 - 4.79X_1X_2$	0.275	1.890	0.676
Overall	$Y = 6.84^*X_1 + 6.53^*X_2 - 3.57^*X_1X_2$	0.370	0.294	0.425
Age 3 (45-55 Years)				
Colour	$Y = 7.25^*X_1 + 7.32^*X_2 - 2.12X_1X_2$	0.226	0.146	0.333
Aroma	$Y = 6.41^*X_1 + 6.40^*X_2 + 0.223X_1X_2$	0.003	0.014	0.381
Taste	$Y = 6.19^*X_1 + 6.64^*X_2 + 1.34X_1X_2$	0.340	2.580	0.304
Overall	$Y = 6.53^*X_1 + 6.76^*X_2 + 0.267X_1X_2$	0.119	0.681*	0.276

Explanation as under Table 1

TABLE 5. USE OF RESPONSE SURFACE MODEL FOR THE PREDICTION OF SENSORY QUALITY OF MIXED FRUIT JUICE BEVERAGES

Blends	Colour	Aroma	Taste	Overall score
LA-60 [Lime :*aonla* (60 :40)]	7.52	6.66	6.57	6.92
LA-40 [Lime : *aonla* (40 :60)]	7.39	6.39	6.34	6.70
MP-60 [Mango : pineapple (60 : 40)]	7.13	6.23	6.07	6.47
MP-40 [Mango : pineapple (40 : 60)]	7.32	6.34	6.19	6.61
GP-60 [Grape : pineapple (60 :40)]	7.02	6.32	6.29	6.54
GP-40 [Grape : pineapple (40 : 60)]	6.79	6.32	6.17	6.43
MG-60 [Mango : grape (60 : 40)]	6.53	6.05	6.14	6.24
MG-40 [Mango : grape (40 : 60)]	6.52	6.00	6.12	6.21

TABLE 6. OPTIMUM RATIOS FOR BLENDING OF JUICES/PULP AND THEIR SENSORY SCORES

Blends	Age group	X_1	X_2	Colour	Aroma	Taste	Overall score
Lime-*aonla*	C	0.779	0.221	7.56	-	-	-
Lime-*aonla*	1	0.891	0.109	7.68	-	-	-
Lime-*aonla*	2	0.589	0.411	7.38	-	-	-
Mango-pineapple	C	0.316	0.684	7.34	-	-	-
Mango-pineapple	C	0.146	0854	-	6.38	-	-
Mango-pineapple	C	0.157	0.843	-	-	-	6.68
Mango-pineapple	1	0.374	0.469	7.34	-	-	-
Mango-pineapple	1	0.053	0.947	-	6.80	-	-
Mango-pineapple	1	0.237	0.763	-	-	-	7.08
Mango-pineapple	2	0.500	0.500	-	6.28	-	-
Mango-pineapple	2	0.240	0.760	-	-	-	6.46
Mango-pineapple	3	0.147	0.853	7.28	-	-	-
Grape-pineapple	C	0.982	0.018	7.18	-	-	-
Grape-pineapple	C	0.511	0.489	-	6.32	-	-
Grape-pineapple	1	0.575	0.425	7.70	-	-	-
Grape-pineapple	1	0.468	0.532	-	7.45	-	-
Grape-pineapple	1	0.554	0.446	-	-	7.13	-
Grape-pineapple	1	0.521	0.479	-	-	-	7.43
Mango-grape	3	0.522	0.478	-	6.46	-	-
Mango-grape	3	0.332	0.668	-	-	6.79	-
Mango-grape	3	0.069	0.931	-	-	-	6.76

C = Combined effect i.e. ignoring the age effect

found to be complementary to each other for the overall quality of the RTS beverages. The negative sign indicated that the blends did not have much effect on the overall quality of the beverages.

Using the fitted model, predicted scores for different beverages were obtained and had been given in Table 5. The optimum combination of X_1 and X_2 using (3) is presented in Table 6 wherever, β_{12} and $\beta_1 - \beta_2 + \beta_{12} > 0$. The scores for the optimum combinations are also presented in Table 6.

Ages of the respondents played an important role in determining the overall quality of the blended beverages. The younger respondents (22-34 years) liked the beverages prepared from mango-pineapple (Table 2) and grape-pineapple blends (Table 3), while the senior respondents (45-55 years) liked the beverages prepared from lime-*aonla* (Table 1) and mango-grape blends (Table 4). This information would be quite useful for food processing industries for targeting a specific group.

While studying the response surface model fitted to different age groups for different beverages, it was observed that the age group 2 (35-44 years) had shown negative response in all the beverages except mango-pineapple in respect of overall sensory quality. In contrast to this, age group 1 (22-34 years) showed positive response in grape-pineapple and mango-pineapple RTS beverages in respect of overall quality. Likewise, age group 3 (45-55 years) showed positive response in lime-*aonla* and mango-grape in respect of overall quality of the beverages.

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RESEARCH NOTE

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Drying of Ginger Using Solar Cabinet Dryer

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Considering the multiple advantages of dried forms of ginger and based on the meteorological data available for the region for last several years, an attempt was made to dry ginger in solar cabinet dryer so that a part of the huge amount of surplus ginger can be saved from post harvest losses and thus farmers can be benefited. From the present study, the solar cabinet dryer was found to be practically useful for drying roughly peeled longitudinally split forms of ginger rhizomes to safe moisture level (less than 10 % moisture) within 4-6 days (15.8-27.3 BSSH). Depending upon the variety, after drying in solar cabinet dryer, there was 0.1 % to 0.23 % decrease of oleoresin in the roughly peeled, split rhizomes in comparison to the same present in the fresh rhizome just after harvest.

Keywords : Safe moisture level, Solar cabinet dryer, Bright sun shine hours (BSSH), Ginger, Sun drying, Moisture content.

India ranks first in the production of dry ginger which is produced mainly in Kerala (George 1996). North East region of India produces about 43540 MT of green ginger annually of which 93.4 % is marketable surplus (Dey 1998). The huge amount of marketable surplus is sold fresh by the farmers at very low price as there is neither improved cheap method to store as fresh for long time (more than six months) nor sun drying is practicable for higher humidity prevailing in the region. Although dry ginger is produced in large amount (33-35 % of the total dry ginger production) in Kerala following sun drying (George 1996), drying of ginger in this region is not practised at all mainly because of lack of knowledge of the farmers about the performance data of the low cost dryers such as solar cabinet dryer. The advantages of solar cabinet dryer includes achievement of higher temperature than the ambient, hence requiring shorter time to dry than sun drying, protection of the products from sudden short term rain and production of dried products in hygienic condition. Considering the advantages of drying which includes reduction in volume, easy handling in transportation, less chance of pest and microbial attack during storage and scope of commercial production of oleoresin, volatile oil and ginger powder, a solar cabinet dryer was used to dry ginger to safe moisture level (less than 10 % moisture). Average meteorological data of the region collected from the Department of Agric Meteorology, AAU for bright sunshine hour, temperature and humidity for last three years during the post harvest period of ginger (November to March) indicated the scope of utilization of solar cabinet dryer to dry ginger in this region. Goyal (2000) also recommended that performance data would be required to establish confidence of public on a particular solar dryer.

Four ginger varieties namely 'Australia', 'Karkai', 'Jati' and 'Moran', which are widely grown in the North East region were selected for the present investigation. The design of the solar cabinet dryer which was used for the present investigation was developed at Rajasthan Agricultural University, Udaipur (Fig. 1). There are 24 trays in the dryer and in each tray about 1500 g fresh ginger rhizome can be spread for drying. Therefore, the capacity of such dryer for ginger is 36 kg rhizome per batch. The drying was conducted in two phases. Based on the first phase of the drying experiment, the second one was planned. In the first experiment which was conducted in early January, just after harvest, the rhizomes were cleaned in water from the adhered soil particles and non rhizome parts. Rhizomes of each of the four varieties were divided in three equal parts for preparation for drying. For this reason, one part (1000 g) of the rhizomes was kept unpeeled and unsplit. The second and third parts (total 2000 g) were split longitudinally and from this one half (1000 g) was roughly peeled whereas the other half (1000 g) was left unpeeled. Then all the three parts of the rhizomes were kept in the trays (48 cm 20 cm 8 cm) of solar cabinet drier separately. 1000 g rhizome was accommodated in one tray, though the capacity of each tray was 1500 g. The same procedure was repeated for sun drying also (control) using the same area for spreading the rhizome as used for solar drying. After specific period (12 days or 76.8 bright sun shine hours BSSH), three samples from each of the three forms of rhizomes of all the varieties were taken out and the moisture content of the rhizome was

TABLE 1. INITIAL AND FINAL MOISTURE CONTENT OF GINGER. SAMPLES DRIED FOR 12 DAYS (76.8 BSSH)

Variety	Treatment	Initial moisture (% w.b.)	Final moisture (% w.b.)	
			Solar dryer dried	Sun dried
'Australia'	a	80.08	11.56	33.49
	b	80.08	3.93	16.38
	c	80.08	2.32	3.37
'Jati'	a	79.27	17.45	21.56
	b	79.27	5.67	15.80
	c	79.27	1.74	8.33
'Karkai'	a	80.33	20.24	27.59
	b	80.33	7.35	13.38
	c	80.33	1.84	9.11
Moran	a	75.93	14.49	21.26
	b	75.93	5.76	7.19
	c	75.93	1.07	3.98

a. Whole rhizome; b. Split unpeeled; c. Split peeled

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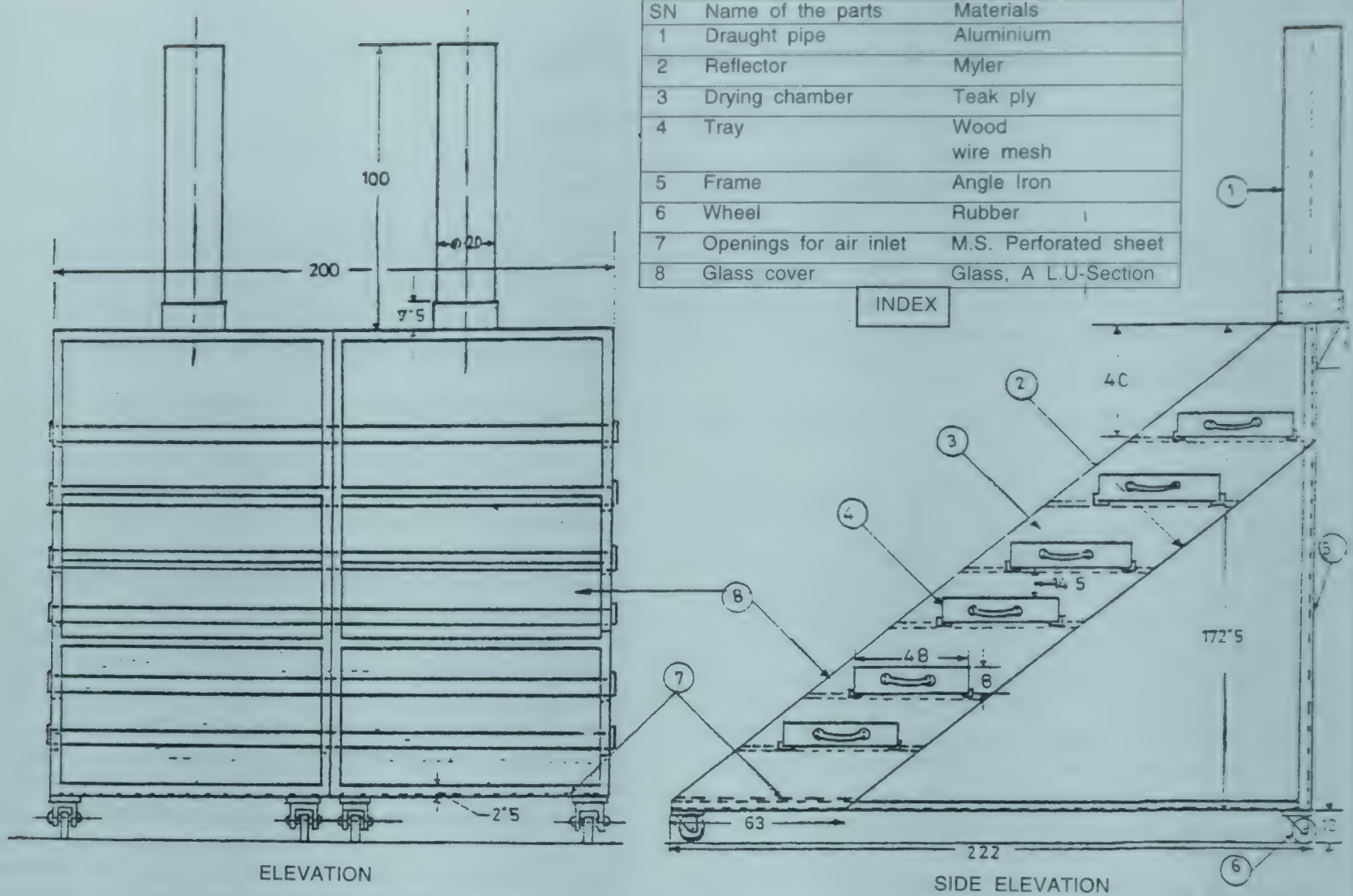

Fig. 1. Solar cabinet dryer (Udaipur Model)

determined according to AOAC (1984) and the mean value obtained.

For the second experiment, conducted during last fortnight of March, variety 'Moran' was eliminated as samples of 'Moran' variety were spoiled due to some unfortunate circumstances. All the three forms of rhizomes (whole unpeeled, split unpeeled and split peeled) were kept in the trays for drying and the average moisture content of the rhizomes were recorded at 48 h interval. Drying was not continued beyond ten days (68.9 BSSH) as it was thought that longer drying time will not be practical. Average oleoresin content/ether extract was determined for solar dryer dried rhizomes according to Oti et al (1988).

The average initial and final moisture contents of the rhizome of all the four varieties (first phase of drying experiment) are presented in Table 1. It was observed that for the whole rhizome, the final moisture level did not fall to safe level (10 % moisture) within 12 days or 76.8 BSSH. For unpeeled split rhizome the final moisture level came down to safe level in all the four varieties dried in solar cabinet dryer. However, for sun drying, only split unpeeled rhizome of 'Moran' variety reached to the safe level after 76.8 BSSH, which may be due

TABLE 2. MOISTURE CONTENT OF GINGER SAMPLES DURING DRYING BY SOLAR DRYER

Duration of drying in days	Duration of drying in BSSH	Moisture content (% on w.b.) 'Australia'			Moisture content (% on w.b.) 'Jati'			Moisture content (% on w.b.) 'Karkai'		
		a	b	c	a	b	c	a	b	c
0	0	80.3	84.8	76.9	86.2	82.3	83.2	76.6	80.9	74.7
2	7.7	78.7	66.8	39.7	84.4	65.8	33.6	75.6	56.3	40.2
4	15.8	77.6	54.3	9.3	83.2	51.4	9.2	73.2	37.3	12.9
6	27.3	76.0	46.2	6.4	82.7	44.8	6.7	70.9	28.4	9.0
8	47.4	74.2	34.4	3.4	82.2	36.2	3.8	68.1	16.6	4.6
10	68.9	72.9	27.6	3.1	81.8	31.1	2.9	65.4	10.6	2.9

a. Whole; b. Split unpeeled; c. Split peeled

TABLE 3. INITIAL AND FINAL OLEORESIN CONTENT OF GINGER. SAMPLES DRIED IN SOLAR CABINET DRIER FOR 10 DAYS OR 68.9 BSSH

Variety	Treatment	Oleoresin content (% d.b.) Initial oleoresin	Final oleoresin
'Australia'	a	2.80	2.60
	b	2.80	2.75
	c	2.80	2.70
'Jati'	a	4.20	5.00
	b	4.20	4.07
	c	4.20	3.97
'Karkai'	a	4.09	2.80
	b	4.09	3.59
	c	4.09	3.95

a. Whole rhizome; b. Split unpeeled; c. Split peeled

to less thickness of the rhizome of this variety. For split roughly peeled rhizome it was observed that within 76.8 BSSH, rhizomes of all the four varieties reached less than 10 % moisture for both solar drying and sun drying.

The moisture content of the rhizomes of three varieties (second phase of drying experiment) are presented in Table 2. It was observed that none of the whole rhizome or unpeeled split rhizome of any variety dried in solar dryer reached 10 % moisture after 10 days or 68.9 BSSH. However, under the same condition of drying, roughly peeled split form of rhizomes of all the three varieties reached to less than 10 % moisture level within 15.8 to 27.3 BSSH.

Data on oleoresin content of the rhizomes are presented in Table 3. One of the components of oleoresin is the volatile oil, which is responsible for imparting flavour to the rhizome. It was observed that average oleoresin content is not affected as depending upon the variety, after drying in solar cabinet dryer, there was 0.1 % to 0.23 % decrease of oleoresin in the roughly peeled, split rhizomes in comparison to the same present in the fresh rhizome just after harvest.

In brief, it was observed that drying using solar cabinet dryer is quicker than sun drying as maximum 20°C raise in temperature than ambient (average 16°C during the first phase of the experiment and 20°C during the second phase of the experiment) is obtained inside dryer. Enhancement of drying by both rough peeling and longitudinal splitting of rhizomes (which is one of the recommended forms of dry ginger) is observed from the present investigation. So, it can be recommended that only this form of rhizome is suitable for drying in solar dryer during post harvest season (November to March) of ginger in Assam. The labour charge required for entire operation of drying, which includes washing, peeling, splitting and spreading the rhizomes has been worked out to be Rs. 3.50 per kg of fresh ginger. In mass process of drying, the cost of drying will become much lower. Accordingly, there is scope for commercial adaptibility of the solar cabinet dryer for drying ginger.

From the results of the present study, it can be recommended that there is much scope for reducing post-harvest losses by adopting the practice of drying of ginger in solar cabinet dryer and this will also lead to the production of oleoresin, volatile oil and ginger powder in this region for which drying is a pre-requisite.

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RESEARCH NOTE

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Studies on Processing of Guava into Pulp and Guava Leather

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Two cultivars namely, 'Allahabad Safeda' and 'Banarsi Surkha' were selected to standardize the method for preparation of guava pulp and guava leather and to study the storage behaviour of these products. The outer skin was removed uniformly by dipping the fruits in 0.5 % sodium hydroxide for 5 min at 98°C. Both cold and hot break methods were found to be equivalent for extraction of pulp. Pulp recovery by cold extraction method was 59.3 and 72.0 % from 'Allahabad Safeda' and 'Banarsi Surkha' respectively. Pulp from the cultivars had different composition. 'Banarsi Surkha' had better quality characteristics. The pasteurized pulp was stored with addition of potassium metabisulphite, sodium benzoate and a combination of both. Composition of pulp and its suitability for the preparation of ready-to-serve drinks were studied during storage. The bottled pulp stored at room temperature with 2000 ppm potassium metabisulphite retained its highly acceptable quality upto six months, as assessed from ready-to-serve drinks prepared from pulp of both the cultivars. Conditions were standardized for the preparation of guava leather from preserved pulp with addition of sugar, followed by drying in cabinet drier at 50 ± 5°C for 4 h to a moisture content of about 29.30 %. The product wrapped in butter paper and packed in polyethylene bags was found to be acceptable up to 3 months under ambient conditions.

Keywords : Guava, Pulp extraction, Pulp recovery, Guava RTS, Guava leather.

Guava is an important commercial fruit of India. It has excellent digestive and nutritive value, pleasant flavour, high palatability and availability in abundance at moderate price. The fresh fruit has limited shelf life. Therefore, it is necessary to utilize this fruit for making different products to increase its availability over an extended period and to stabilize the price during glut season. A number of products are being prepared from this fruit including jam, jelly and slices in syrup (Lal et al. 1967; Harnanan et al. 1980; Singh and Dhawan 1983). These products have good potential for internal as well as external trade. The utilization of guava for the preparation of beverages and intermediate moisture products has not been explored much. Guava pulp can be used as base for the preparation of these products. The present work was conducted with the objectives i) to standardize a method for the preparation of guava pulp, to study the effect of storage on quality of pulp, as well as its suitability for preparation of ready-to-serve drinks and ii) to standardize a method for the preparation of guava leather and ascertain its storage behaviour.

Two cultivars namely 'Allahabad Safeda' (A) 'Banarsi Surkha' (B) were selected for the study. The washed fruits were dipped (as determined by preliminary experiments) in 0.5 % sodium hydroxide for 5 min. at 98°C. The ratio of fruit to solution was 1:5 the treated fruits were washed under tap water to remove skin. The stem and blossom ends were removed manually.

Extraction of pulp : The pulp was extracted from lye treated fruits by using superfine pulper (Raylons, India) with a 32 mesh size sieve by three different methods; first by cold extraction method in which the fruits were fed into pulper without heating; second after dipping the pieces of fruits in boiling water for 2 min. and third after autoclaving the fruits at 10 psi for 4 min. Pulp was pasteurized at 85°C for 3 min. with addition of small amount of citric acid to raise the titrable acidity to approximately 0.5 %. Chemical preservatives including potassium metabisulphite (2000 ppm; A1 and B1), sodium benzoate (750 ppm; A2 and B2) and a combination of potassium metabisulphite (1000 ppm) and sodium benzoate (375 ppm) (A3 and B3) were added to the pulp after dissolving in small quantity of water and mixed thoroughly before filling into 650 ml. capacity plain beer bottles. The bottles were crown corked and stored under ambient conditions (10-38°C) for 6 months.

Preparation of guava leather : Guava leather was prepared from pulp of 'Banarsi Surkha' having acidity 0.4 % after adjustment of total soluble solids to 20 %. The pulp was dried in thin layers (0.5 cm) in cabinet cross flow drier at 50 ± 5°C for 4 h. The semi dried product was folded to make a thick slab and wrapped in butter paper and packed in polyethylene bags (100 gauge) and stored under ambient conditions (18-37°C RH 41-76 %).

Preparation of ready-to-serve drinks : These were prepared from stored pulp with 20 % pulp, 12 % total soluble solids and 0.3 % acidity. The organoleptic quality of products was evaluated by a panel of 10 judges on 9-point Hedonic scale (Amerine et al. 1965).

Chemical constituents : The analytical parameters i.e. total soluble solids, moisture, titratable acidity, pH, ascorbic acid, reducing sugars, total sugars, pectin, sulphur dioxide and ash contents were determined by standard analytical (AOAC 1970) methods. Non-enzymatic browning was determined by extraction of 5 g sample with 60 % (25 ml) ethanol and determining the optical density at 440 nm with Spectronic-20 (Ranganna 1977). The water activity of guava leather was determined by graphical interpolation method as described by Jayaraman et al (1977).

Pulp analysis : Results of analysis of the pulp (Table 1) showed that there was a slight increase in the pulp recovery by the hot break methods of extraction. Different methods of extraction did not show remarkable difference in total soluble solids, moisture, acid, ascorbic acid and pectin contents of

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TABLE 1. EFFECT OF EXTRACTION METHOD ON YIELD AND COMPOSITION OF GUAVA PULP

Parameter	Extraction method		
	Cold extraction	Hot water boiling for 2 min.	Autoclaving 10 PSI for 4 min.
Pulp yield, %	70.0	71.30	72.00
Total soluble solids, %	8.20	8.20	8.20
Moisture, %	84.30	84.20	84.10
Acidity, %	0.35	0.37	0.36
Reducing sugars, %	3.60	4.00	3.58
Total sugars, %	4.21	5.13	4.72
Ascorbic acid mg, %	106.90	104.10	106.70
Pectin, %	0.60	0.62	0.63

TABLE 2. COMPOSITION OF GUAVA PULP OF TWO CULTIVARS

Parameter	'Allahabad Safeda' (A)	'Banarsi Surkha' (B)
Total soluble solids, %	7.20	9.40
Moisture, %	87.79	81.80
Acidity, %	0.48	0.55
Reducing sugars, %	3.32	3.55
Total sugars, %	4.40	4.64
Ascorbic acid, mg %	31.16	74.01
Pectin, %	0.47	0.67
pH	3.97	3.81
Ash, %	0.60	0.49
Pulp recovery, %	59.30	72.00
Peeling losses, %	5.50	6.30

pulp. The reducing and total sugar contents were found to be slightly on the higher side in pulp, extracted by hot break methods and this may be attributed to the hydrolysis of labile polysaccharides into sugars at elevated temperatures. Contradictory results have been reported by Harnanan et al (1980) and Jain and Borkar (1968) regarding the merits of cold and hot extraction methods. The former reported the merits of cold extraction method being superior in quality, whereas the latter found the hot method the best for preparation and preservation of guava pulp. However, all the three methods of extraction were found almost equivalent in the present study.

Table 2 shows that 'Banarsi Surkha' had better quality characteristics than 'Allahabad Safeda'. Moreover, the pulp recovery was 12.70 % more from 'Banarsi Surkha' and it was superior in flavor than 'Allahabad Safeda'. Peeling losses were slightly higher in 'Banarsi Surkha'. The effect of storage on chemical composition and organoleptic quality of guava pulp from 'Allahabad Safeda' and 'Banarsi Surkha' has been given in Tables 3 and 4, respectively. There was a considerable increase in total soluble solids of pulp during storage, which may be due to increase in sugars, acidity and other soluble materials. Tandon and Kalra (1984) reported increase in total soluble solids of guava pulp during storage. The decrease in moisture content of pulp with different treatments was 2.32-3.09 % in 'Allahabad Safeda' and 2.37-3.26 % in 'Banarsi Surkha'. The acidity of pulp from both the cultivars increased

TABLE 3. EFFECT OF STORAGE (SIX MONTHS) ON COMPOSITION AND QUALITY OF PULP FROM 'ALLAHABAD SAFEDA'

Parameter	Treatment					
	A1		A2		A3	
	Initial	Final	Initial	Final	Initial	Final
Total soluble solids, %	7.20	7.90	7.20	8.00	7.30	8.00
Moisture, %	87.79	85.07	86.17	84.24	87.73	85.07
Acidity, %	0.48	0.54	0.53	0.68	0.45	0.52
Reducing sugars, %	3.32	5.90	3.71	6.15	2.71	4.60
Total sugars, %	4.40	6.27	4.82	6.20	4.42	5.45
Ascorbic acid, mg. %	31.16	20.12	34.73	16.17	36.97	20.50
*Pectins, %	0.47	0.49	0.41	0.38	0.43	0.40
pH	3.97	3.60	3.82	3.45	3.97	3.69
*Ash, %	0.60	0.61	0.61	0.62	0.61	0.59
*Non enzymatic browning OD at 440 nm	0.010	0.011	0.011	0.030	0.010	0.013
Sulphurdioxide, ppm.	1030	410	-	-	409	165
*Overall acceptability mean score (RTS)	8.13	7.86	7.96	6.99	7.93	7.73

*Mean values do not differ significantly at CD, p = 0.05
A1 = Pulp stored with potassium metabisulphite 2000 ppm; A2 = Pulp with sodium benzoate 750 ppm; A3 = Pulp stored with potassium metabisuphite 1000 ppm and sodium benzoate 375 ppm

TABLE 4. EFFECT OF STORAGE (SIX MONTHS) ON COMPOSITION AND QUALITY OF PULP FROM 'BANARSI SURKHA'

Parameter	Treatment					
	B1		B2		B3	
	Initial	Final	Initial	Final	Initial	Final
Total soluble solids, %	9.40	9.60	9.50	9.60	9.50	9.60
Moisture, %	81.80	79.13	81.83	79.89	81.83	79.97
Acidity, %	0.55	0.61	0.51	0.65	0.35	0.42
Reducing sugars, %	3.55	5.99	3.92	6.06	3.79	6.16
Total sugars, %	4.64	6.35	5.09	6.43	5.43	7.08
Ascorbic acid, mg. %	74.01	51.02	69.11	36.07	62.88	36.47
*Pectins, %	0.67	0.69	0.59	0.59	0.63	0.65
pH	3.81	3.60	3.90	3.48	4.20	3.66
*Ash, %	0.49	0.48	0.48	0.48	0.48	0.49
*Non-enzymatic browning OD at 440 nm	0.011	0.014	0.012	0.020	0.011	0.016
Sulphurdioxide, ppm.	1127	635	-	-	550	247
*Overall acceptability mean score (RTS)	8.06	8.00	7.93	7.78	7.96	7.86

*Values do not vary significantly at CD, p=0.05
B1 = Pulp stored with potassium metabisulphite 2000 ppm; B2 = Pulp with sodium benzoate 750 ppm; B 3 = Pulp stored with potassium metabisuphite 1000 ppm and sodium benzoate 375 ppm

TABLE 5. EFFECT OF STORAGE ON COMPOSITION OF GUAVA LEATHER

	Storage period (months)			
Parameter	Initial	1	2	3
Total soluble solids, %	50.60	51.50	51.90	52.20
Moisture, %	29.30	27.00	22.00	21.50
*Acidity, %	0.41	0.41	0.42	0.44
Reducing sugars, %	6.12	8.90	9.12	9.93
Total sugars, %	38.29	39.57	40.33	44.39
Ascorbic acid, mg. %	76.50	69.10	65.30	64.60
*Pectin, %	1.20	1.19	1.20	1.18
*Ash, %	1.21	1.20	1.21	1.19
Sulphur dioxide, ppm	416.00	327.00	302.00	272.00
Overall organoleptic mean score	8.33	8.16	8.13	7.13

*Values do not differ significantly at CD, p = 0.05

in all the treatments. The percent increase was greater in 'Banarsi Surkha' than in 'Allahabad Safeda'. The maximum increase was observed in samples preserved with sodium benzoate alone while minimum increase was recorded in pulp preserved with potassium metabisulphite 2000 ppm. The pH of both the cultivars showed a downward trend during storage. The results of changes in acidity and pH are in conformity with those reported by Tandon et al (1983). The reducing sugar contents of pulp increased remarkably during storage. The changes in reducing sugars may be attributed to inversion of non-reducing sugars to reducing sugars by acid hydrolysis. The total sugars increased in stored pulp, the extent of increase was more in 'Allahabad Safeda' than 'Banarsi Surkha' which may be due to conversion of starch into sugars. Harnanan et al (1980) reported increase in both reducing and non-reducing sugars in stored guava pulp. There was significant decrease in ascorbic acid content of all the samples. Maximum losses of 53.45 and 47.81 % were recorded in pulp preserved with sodium benzoate 750 ppm in 'Allahabad Safeda' and 'Banarsi Surkha' respectively. Maximum retention of ascorbic acid was found in pulp stored with potassium metabisulphite 2000 ppm, showing that sulfur dioxide helped in greater stability of ascorbic acid (Diaz Delgado and Villalobos Cruz 1974). The pectin content was not affected much with very minor changes in different samples, thus showing non-significant effect of storage. Similar trends were observed in ash content. The non-enzymatic browning was found to be higher in 'Banarsi Surkha' as compared to 'Allahabad Safeda'. The extent of browning was maximum in samples stored with sodium benzoate alone. The added sulphur dioxide decreased in pulp and reduction in concentration was more in 'Allahabad Safeda' having lower ascorbic acid content. The higher ascorbic acid content in 'Banarsi Surkha' probably resulted in lower losses of sulphur dioxide.

The organoleptic quality of all the samples as assessed from the ready-to-serve drinks prepared from stored pulp, was found acceptable, though the samples stored with potassium metabisulphite (2000 ppm) retained better acceptability. 'Banarsi Surkha' retained slightly better overall organoleptic mean score during storage.

Quality of guava leather : The composition and effect of storage on composition and quality of guava leather are given in Table 5. It was found that fresh guava leather with given composition had good organoleptic acceptability. The water activity of the product was 0.74. Jayaraman et al (1974) reported water activity of 0.75 in intermediate moisture guava prepared by immersion-equilibrium procedure. The product was found to be acceptable upto three months under ambient conditions, though there was a decrease in overall organoleptic scores from 8.33 to 7.13 during three months of storage, which was mainly due to increase in browning.

Conclusion

It may be concluded that pulp of good quality can be prepared both by cold and hot extraction methods after lye peeling of fruits. The yield and quality of pulp from 'Banarsi Surkha' was better than that obtained from 'Allahabad Safeda'. The pasteurized bottled pulp from both cultivars could be stored with addition of chemical preservatives upto six months. The pulp preserved with potassium metabisulphite (2000 ppm) retained better quality than other treatments. Guava leather prepared from pulp had good organoleptic acceptability and had a shelf life of three months under ambient conditions.

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RESEARCH NOTE

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Studies on Dehydration and Pre-treatment Level to Control Browning and Storage of Onion Flakes

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Dehydration of white and red colour onion varieties was carried out in cross flow drier at different temperatures viz., 50°C, 60°C and 70°C with different sulphitation levels as pre-treatments viz., 0.2 %, 0.3 % and 0.4 % in order to control the discolouration and to produce value-added products with increased shelf life. The time required for dehydration was comparatively lesser for the sulphited than control samples of white onion at all the selected temperatures. From the biochemical analyses of the dehydrated flakes, it was observed that the ascorbic acid retention was comparatively higher at 50°C with 0.4 % sulphitation and the non-enzymatic browning was significantly less at 60°C with 0.3 % sulphitation. From the organoleptic studies, it was also observed that the onion flakes dehydrated at 60°C with 0.3 % sulphitation level scored the maximum points. A progressive increase in moisture content and decrease in ascorbic acid were observed during storage.

Keywords : Cross flow drier, Potassium meta bisulphite (KMS), Dehydration, Onion flakes, Storage, Discolouration, Organoleptic evaluation.

Consumption of dehydrated onion flakes is becoming popular in the recent days. There are several dehydration units in India, which produce dehydrated onion flakes for export as well as for domestic consumption. But during commercial dehydration of white and red onion flakes, pink discolouration often adversely affects the quality of dried onion flakes. Control of pink discolouration is very much important to attract the consumer and also to compete in the market. Several authors (Munde et al 1988; Pawar et al. 1988; Raina et al. 1988; Sharma and Nirankarnath 1991; Singh and Mohan Kumar 1984; Wang 1992) have investigated the dehydration of onion. But those studies were mostly concerned with evaluation of drying characteristics, varietal differences in the quality of the dehydrated product. But the information on the related aspects of pre-treatment levels, optimum temperatures and methods of packing and storage to improve the shelf life of dehydrated onion flakes are very limited. The present investigation was therefore, undertaken to study the dehydration and pre-treatment levels to control browning and storage of onion flakes.

Two varieties of onion bulbs namely 'Pusa white round' and 'Agrifound dark red' were procured locally for the experimental study.

Physical characteristics : Ten onion bulbs from each variety were selected for the measurement of physical characteristics such as diameter, length and weight.

Dehydration : All the pre-treated samples and control sample were spread uniformly at the rate of 2 kg per tray of size 90 cm x 40 cm, dried in cross flow drier at 50°C, 60°C and 70°C respectively. The losses in weights by the slices were determined at an hourly interval. Drying was terminated when the sample attained a weight corresponding to 5-7 % moisture content. Onion slices were dried about 5-8 h depending upon the selected temperatures. Drying ratio was recorded as the dried weight of the product to the weight before drying of the material.

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Rehydration : As per ISI standards, for every rehydration test, 30 g of the dehydrated onion flakes were rehydrated by steeping in 250 ml of distilled water for 4 h. The rehydration ratio was computed as the weight of the rehydrated sample to that dehydrated sample.

Chemical analysis : Good quality onion bulbs from each variety were selected for chemical analysis. Moisture content was determined by drying the sample in a vacuum oven at 100°C to constant weight (Osborne and Voogt 1978). Ascorbic acid content was estimated by titrating a known weight of the sample, with 2, 6 dichlorophenol indophenol dye (Sadasivam and Manickam 1990). Total solid matter was determined by drying known weight of the onion slices in the oven at 100°C to constant weight (Osborne and Voogt 1978). Total water insoluble matter was determined by washing onion paste free from soluble matter with water on a weighted filter paper and drying it in the oven at 100°C to a constant weight (Osborne and Voogt 1978). Total sugar in onion was determined by taking an aliquot of the clarified extract following hydrolysis with hydrochloric acid and neutralization of the excess acid with sodium carbonate (Sadasivam and Manickam 1990). Browning or discolouration of dehydrated onion flakes was assessed by measuring the optical density at 420 nm from an aliquot extract of 100 % alcohol.

Pre-dehydration preparation and pre-treatments : Onions with uniform size from each variety were selected for the experimental study. After peeling and trimming, the onion bulbs were sliced at right angles to the vertical axis with a sharp stainless steel knife to obtain slices of 3-4 mm thickness. Sulphitation was carried out by steeping the slices in 0.2 %, 0.3 % and 0.4 % potassium meta bisulphite solution for 5 min (Pawar et al. 1988). Pre-treated sample in each level and control sample (without pre-treatment) were dried at the drying air temperature of 50°C, 60°C and 70°C respectively.

Organoleptic evaluation : Organoleptic evaluation of dehydrated onion slices was performed to select the best sample among the dehydrated white and red colour onions

flakes in terms of colour, texture, pungency and overall acceptability by a panel of 5 judges in a 9-point Hedonic scale, varying from like extremely to dislike extremely (Ranganna 1979).

Packaging and storage studies : The best sample obtained from white and red colour dehydrated flakes were packed in 300 gauge thick polyethylene bags and storage studies were carried by adopting three methods of storage namely, vacuum storage, storage in polyethylene bags filled with nitrogen and control storage (air filled) for a short period of three months at room temperature ranging from 23-30°C. The biochemical changes and organoleptic evaluations were also carried out at monthly interval.

Physico-chemical characteristics : The physio-chemical characteristics of the white and red onions used for drying studies are tabulated in Table 1. It can be seen from the Table that, the size of the varieties in the present study was within the desirable limits for processing as in practice. Onions with more than 4.0 cm dia are considered suitable for processing (Sethi et al. 1973). The moisture content ranged from 87.8 % in red variety to 88.4 % in 'Pusa white round' variety. The total solids as determined by oven method was comparatively higher in (12.2 %) 'Pusa white round' than in 'Agrifound red' variety (11.6 %). The ascorbic acid content was higher in red onion (10.9 mg/100 g) than in white onion (10.5 mg/100 g). Total sugars in red onion is slightly higher than in white onion. The water insoluble matter in red onion (2.2 %) is slightly lower than that of white onion (2.3 %). These values in the present study are broadly comparable with the corresponding values reported by Kalra et al (1987).

Technical data on dehydration : On an average, 5 to 7 slices were recovered for dehydration from the red and white bulbs under this study. The dehydration characteristics of white and red onion flakes are presented in Table 2. From the

TABLE 1. PHYSIO-CHEMICAL CHARACTERISTICS OF WHITE AND RED ONION VARIETIES

Particulars	'Pusa white round'	'Agrifound dark red'
Average weight, g	58.31	57.26
Average length, cm	5.21	5.25
Average diameter, cm	5.17	4.88
Moisture content, wb %	88.40	87.80
Total solids, %	12.20	11.60
Ascorbic acid, mg/100 g	10.50	10.90
Total sugars, %	6.12	6.23
Water insoluble matter, %	2.30	2.20

TABLE 2. DEHYDRATION CHARACTERISTICS OF WHITE AND RED ONION FLAKES

Tempe-rature °C	Sulphi-tation level, %	Variety	Drying time, min	Final moisture content, wb %	Drying ratio	Rehy-dration ratio
50	0.0	W	540.00	5.89	7.71	5.01
		R	590.00	6.60	8.05	4.99
	0.2	W	480.00	5.76	7.91	5.07
		R	590.00	6.41	8.32	5.08
	0.3	W	480.00	5.55	7.93	5.10
		R	560.00	6.70	8.32	5.12
	0.4	W	480.00	5.25	8.04	5.09
		R	560.00	5.50	8.46	5.12
60	0.0	W	390.00	5.79	7.72	4.97
		R	420.00	5.69	8.13	4.99
	0.2	W	360.00	6.60	7.84	5.09
		R	420.00	5.50	8.36	5.07
	0.3	W	360.00	5.55	8.02	5.12
		R	360.00	5.53	8.33	5.11
	0.4	W	360.00	5.07	8.03	5.13
		R	360.00	5.20	8.38	5.12
70	0.0	W	330.00	5.77	7.74	4.95
		R	330.00	6.70	8.04	4.95
	0.2	W	300.00	6.20	7.87	5.07
		R	300.00	7.01	8.22	5.08
	0.3	W	300.00	5.70	7.94	5.13
		R	300.00	6.13	8.31	5.13
	0.4	W	300.00	5.17	8.02	5.13
		R	300.00	5.36	8.37	5.12

W - White; R - Red

TABLE 3. CHEMICAL COMPOSITION OF DEHYDRATED WHITE AND RED ONION FLAKES

Tempe-rature °C	Sulphita-tion level, %	Variety	Ascorbic acid, mg/100 g	Total sugars,%	Non-enzymatic browning (O.D)
50	0.0	W	4.15	5.10	145
		R	4.19	5.16	140
	0.2	W	6.31	4.98	77
		R	6.35	5.08	75
	0.3	W	6.79	4.92	49
		R	6.75	4.97	49
	0.4	W	6.86	4.86	50
		R	6.98	4.93	52
60	0.0	W	4.19	5.08	167
		R	4.22	5.14	165
	0.2	W	6.28	4.10	89
		R	6.38	5.05	91
	0.3	W	6.76	4.91	45
		R	6.80	4.97	52
	0.4	W	6.80	4.85	46
		R	6.95	4.86	49
70	0.0	W	4.10	5.06	224
		R	4.21	5.11	248
	0.2	W	6.16	4.97	198
		R	6.39	4.98	222
	0.3	W	6.28	4.91	172
		R	6.77	4.92	180
	0.4	W	6.30	4.93	175
		R	6.93	4.82	176
	CD (5 %)		0.015	0.014	0.7

W - White; R - Red

TABLE 4. CHEMICAL COMPOSITION OF DEHYDRATED WHITE AND RED ONION FLAKES DURING STORAGE

Storage days	Storage methods	Variety	Final moisture content, %	Ascorbic acid, mg/100 g	Total sugars, %	Non-enzymatic browning, &	Rehydration ratio (O.D.)
50	C	W	5.62	6.74	4.95	47.5	5.10
		R	5.58	6.76	5.01	49.0	5.10
	V	W	5.58	6.75	4.95	46.0	5.11
		R	5.59	6.78	4.97	48.0	5.10
	N	W	5.59	6.75	4.94	47.0	5.11
		R	5.57	6.78	4.98	49.0	5.10
60	C	W	5.71	6.40	4.97	50.0	5.08
		R	5.68	6.41	5.09	51.5	5.07
	V	W	5.68	6.49	4.96	48.0	5.08
		R	5.66	6.49	5.00	50.0	5.08
	N	W	5.70	6.45	4.96	47.0	5.08
		R	5.67	6.46	4.98	51.5	5.06
70	C	W	5.85	6.09	5.11	52.5	5.04
		R	5.82	6.11	5.12	52.0	5.05
	V	W	5.83	6.12	5.00	50.0	5.06
		R	5.81	6.14	5.05	54.0	5.04
	N	W	5.84	6.11	5.02	51.5	5.05
		R	5.82	6.13	5.02	53	5.04
	CD (5 %)			0.006	0.004	0.9	

C = Control storage; V = Vacuum storage; N = Nitrogen filled bag storage; W = White; R = Red

Table, it can be observed that the sulphitation with varying level of potassium metabisulphite (KMS) gave the product with varying characteristics at different drying temperatures for the red onion variety. But for the white variety, the sulphited samples required less drying time than the samples dried without sulphitation at all the temperatures. According to Pawar et al (1988), sulphitation increases energy absorption by the product leading to elevated product temperature and shorter drying time. It was also observed that, the drying time was not changed with increasing level of sulphitation viz., 0.2 %, 0.3 % and 0.4 % at 70°C for both the varieties.

The drying ratio ranged from 7.71 to 8.46 for white and red onion under cross flow drying. The rehydration ratio of dehydrated white and red onion ranged from 4.95 to 5.13.

Organoleptic evaluation of dehydrated onion slices : The analysis of variance based on organoleptic scores of dehydrated onion flakes showed that the factors selected were adequate and suitable for consumption. From the organoleptic studies it was found that the white and red onion slices dehydrated at 60°C with 0.3 % KMS scored the maximum points. Hence these samples were taken for storage studies. Biochemical analyses were also carried out for the dehydrated samples. These values were statistically analysed as factorial randomised block design and presented in Table 3, which shows that the ascorbic acid retention was comparatively higher at 50°C with 0.4 % KMS. The sugar content was significantly higher at 50°C and the non-enzymatic browning or discolouration was significantly less at 60°C with 0.3 % KMS. This shows that the sulphitation of onion flakes helped in retention of ascorbic acid and its natural colour. At the same time, the sugar content was reduced due to sulphitation.

Changes in quality during storage : The sorption and biochemical changes were observed at monthly interval for the onion flakes dehydrated at 60°C with 0.3 % of KMS. During the storage period of three months (Table 4), it was found that the moisture content was increased marginally in all storage methods. A significant reduction in ascorbic acid was observed in all the methods of storage and the reduction was comparatively higher in control or aerated sample. The total sugar content was slightly higher in control sample. The change in browning or discolouration was comparatively lesser at vacuum storage followed by nitrogen filled pack storage. Dehydrated onion flakes are used as such for the preparation of fried items and for other culinary preparations, rehydrated onion flakes are to be used.

From the results of this study, it may be concluded that the browning was comparatively lesser at 60°C with 0.3 % sulphitation level and the dehydrated onion flakes could be preserved very well in vacuum packs for consumption during the storage period.

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RESEARCH NOTE

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Relationship Between Parboiling, Degree of Milling, Ash Distribution and Conductivity in Rice

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Three Indian rice cultivars varying in length to breadth ratio were parboiled and evaluated for their milling characteristics. The raw and parboiled rice samples were milled for 0, 20, 40, 60, 80 and 100 sec in the McGill No. 2 rice miller and tested for degree of milling, ash distribution pattern and conductivity. Parboiled rice samples from all the three rice cultivars showed a lower degree of milling as compared to raw rice for the same milling duration. Parboiling led to a significant increase in the ash content and conductivity values in all the three rice cultivars. A strong relationship between degree of milling and conductivity existed and the R^2 values (0.93-0.99) indicated that degree of milling could be predicted using conductivity.

Keywords : Parboiling, Ash content, Degree of milling, Conductivity, Brown rice, Milled rice.

Parboiling of paddy is an age-old practice in which paddy is steeped in water, steamed and then dried. This is followed by milling into parboiled rice popular in some parts of the world. The change in mineral content namely inward migration of total ash and phosphorus is one of the many changes which occurr in rice during parboiling (El Baya and Ahmed 1972, Balling and El Baya 1975). Bhattacharya and Ali (1985) reported that the total ash content is more in parboiled rice than the milled raw rice.

The weight percentage of bran removed from brown rice is a term commonly used to express the degree of milling. The higher the degree of milling the more the bran has been removed from the kernel and thus whiter the rice. A lower degree of milled rice has a greater nutritional value but has a lower market appeal because most consumers prefer the appearance of white rice. Therefore adjusting the degree of milling during the rice milling operations is essential for optimizing quality and economic returns. Other methods, which have been developed to determine the degree of milling of milled rice are, surface fat (Siebenmorgen and Sun 1994), thiamine and phosphorus contents (Desikachar 1955) of milled rice, the optical methods (Fant et al. 1994, Delwiche et al. 1996), digital image analysis (Liu et al. 1998) and conductivity method (Singh et al. 1998, 2000). The present communication deals with the effect of parboiling on ash content and conductivity of brown rice, to relate degree of milling with ash content and conductivity in raw and parboiled rice and to relate ash content and conductivity in parboiled and raw rice.

Preparation of samples : Three different rice cultivars from the 1998 harvest ("Jaya", 'PR-106" and "Pusa No. 1") varying in length to breadth ratio (2.71, 3.48 and 4.23), respectively were collected from the Punjab Agriculture University Rice Research Station. The mean moisture content of these samples was 12 %. The paddy was soaked in water at 25°C for 48 h to a moisture content of 28.6 % (wb) and was then steamed at 100°C for 20 min at atmospheric pressure in an autoclave. The steamed paddy was dried in a cabinet drier at 45°C to a moisture content of 12 % (wb).

Milling : The samples were dehusked in a McGill Rice Sheller (Rapsco, Brookshire, TX, USA) and the whole brown rice kernels (150 g) separated from the brokens were milled again in triplicate in a McGill MIller No 2 (Rapsco, Brookshire, TX, USA) for 0, 20, 40, 60, 80 and 100 sec at (660 g) pressure. The milled materials was ground to pass through a 50 mesh sieve in a laboratory grinder.

Conductivity : Each sample (1 g, dry weight basis) was dispersed with 25 ml of deionized water for 30 min at 25°C with stirring after every 5 min. The material was then centrifuged at 4000 g for 5 min and the supernatant was collected and analysed for conductivity. The conductivity was measured using a Digital Conductivity Meter (Model CM-183, EC-TDS Analyzer Elico Pvt. Ltd., Hyderabad), a dip type conductivity cell with a cell constant of 1.0 was used in all the measurements to ± 0.5 % accuracy. The ash content of all samples was determined using the AACC (1995) method. The data reported for degree of milling, ash content and conductivity is an average of three observations.

Relationship between degree of milling and milling duration : Fig. 1 illustrates the effect of milling duration on percent bran removed in raw and parboiled rice. All the cultivars differed significantly with respect to degree of milling under similar conditions and highest degree of milling was for "PR-106" and lowest in "Pusa No-1". These differences may be attributed to the variation in percent chalky kernels and hardness (Van Ruiten 1985). Milling of brown rice obtained from parboiled paddy showed a lower removal of bran comparaed to that from raw paddy rice of different cultivars

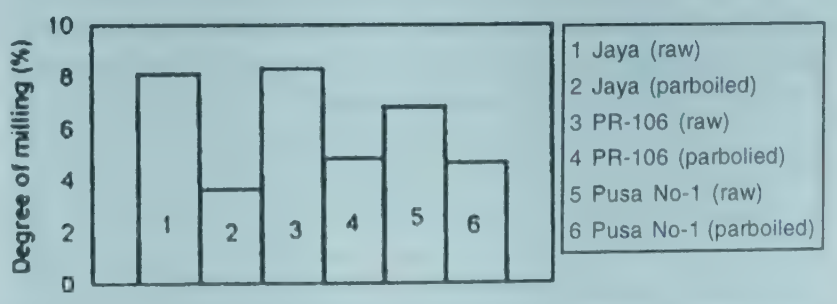

Fig. 1. Degree of milling of raw and parboiled rice from different rice cultivars milled for 100 seconds

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TABLE 1. RELATIONSHIP BETWEEN DEGREE OF MILLING, ASH CONTENT, MILLING DURATION AND CONDUCTIVITY

Cultivar	Polynomial equation	R^2
"Jaya" (raw)	$y = -0.0004 x^2 + 0.1197 x + 0.5$	0.996
"Jaya" (parboiled)	$y = -0.0006 x^2 + 0.0897 x + 0.3$	0.960
'PR-106" (raw)	$y = -0.0007 x^2 + 0.1479 x + 0.5$	0.966
"PR-106" (parboiled)	$y = -0.0007 x^2 + 0.1128 x + 0.4$	0.933
"Pusa No. 1" (raw)	$y = -0.0004 x^2 + 0.1048 x + 0.03$	0.997
"Pusa No. 1" (parboiled)	$y = -0.0007 x^2 + 0.1102 x + 0.1$	0.976
"Jaya" (raw)	$z = 0.00001 x^2 - 0.0166 x + 1.0$	0.974
"Jaya" (parboiled)	$z = 0.00003 x^2 - 0.0047 x + 1.1$	0.961
"PR-106" (raw)	$z = 0.0001 x^2 - 0.0222 x + 1.3$	0.962
"PR-106" (parboiled)	$z = 0.00007 x^2 - 0.0134 x + 1.4$	0.998
"Pusa No. 1" (raw)	$z = 0.00008 x^2 - 0.0147 x + 1.3$	0.980
"Pusa No. 1" (parboiled)	$z = 0.00002 x^2 - 0.0062 x + 1.4$	0.989
"Jaya" (raw)	$c = 0.0025 x^2 - 0.837 x + 298$	0.994
"Jaya" (parboiled)	$c = -0.00009 x^2 - 0.1668 x + 304$	0.987
"PR-106" (raw)	$c = 0.0015 x^2 - 0.7561 x + 283$	0.973
"PR-106" (parboiled)	$c = -0.0006 x^2 - 0.0363 x + 306$	0.983
"Pusa No. 1" (raw)	$c = 0.0054 x^2 - 1.3332 x + 301$	0.973
"Pusa No. 1" (parboiled)	$c = 0.0011 x^2 - 0.2402 x + 311$	0.967

c = conductivity, x = milling duration, z = ash content, y = degree of milling

under similar milling conditions. This may be attributed to hardening of the rice kernel upon parboiling (Raghavendra Rao and Juliano 1970). The degree of milling for 100 sec duration of raw "Jaya", "PR-106" and "Pusa No. 1" was 4.46, 3.48 and 2.8 %, respectively higher as compared to their parboiled counterparts. The greater adhesion between starch granules and protein in parboiled rice lead to increased hardness (Pillaiyar and Mohandoss 1981). In parboiled brown rice the degree of milling was highest in "Pusa No-1" and lowest in "Jaya". These differences may be attributed to differences in shape of the kernels, as "Jaya" has broader shaped kernels, whereas "PR-106" and Pusa No 1. has slender shaped kernels. Matthew's and Spadaro (1976) reported that the amount of bran (weight of bran per unit brown rice weight) removed in milling increased with decrease in rough rice kernel thickness. The coefficients of determination for the polynomial relationships were higher in case of raw rice than for parboiled rice (Table 1).

Relationship between ash content and milling duration: Fig. 2 shows the effect of milling duration on ash content of brown rice from raw and parboiled rice from different cultivars. The brown rice obtained from different cultivars differ significantly with respect to ash content. Parboiling resulted in an increase in the ash content for all the paddy rice cultivars. The ash content of unpolished "Jaya", "PR-106" and "Pusa No. 1" was 2.68, 7.8 and 4.08% respectively higher than their brown raw counterparts. This indicates that there is diffusion of minerals into the rice kernel during the steeping and steaming process. Raw rice had lower ash contents than parboiled rice after each successive milling duration. The ash content decreased by 63.72. 68.84 and 52.51 % when the raw "Jaya", "PR-106" and "Pusa No. 1" were milled for 100 sec

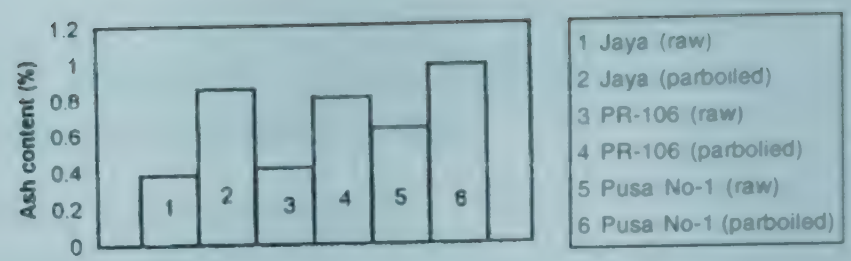

Fig. 2. Ash content of raw and parboiled rice from different rice cultivars milled for 100 seconds

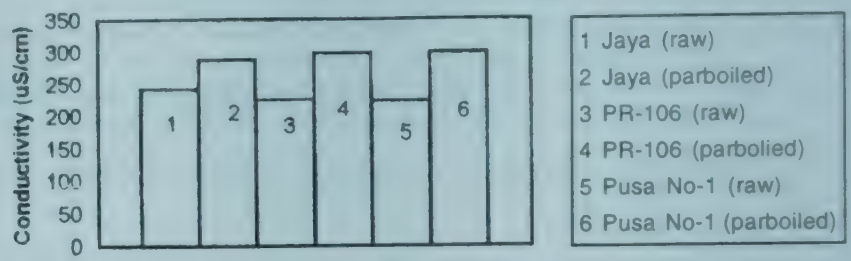

Fig. 3. Conductivity of raw and parboiled rice from different rice cultivars milled for 100 seconds

whereas the ash content decreased by 20.46, 44.22 and 28.81 % in case of their parboiled counterparts. The higher decrease in ash content after milling in raw rice is clearly due to the higher degree of milling in case of raw rice. The percent reduction in ash content was greater with increasing degree of milling since the concentration of ash in the outer bran layers of brown rice is more than in the endosperm (Juliano and Bechtel 1985). The relationship between ash content and milling duration for raw and parboiled rice is described by equations in Table 1. In all the cultivars, the constants of the equations were higher in case of parboiled rice than the constants for raw rice.

Relationship between electrical conductivity and milling duration : Fig. 3 illustrates the effect of milling duration on the electrical conductivity of rice obtained from different cultivars. Conductivity progresively decreased with the increase in milling duration in all the rice cultivars. Parboiling resulted in an increase in the conductivity of brown rice from different cultivars. The conductivity values were higher by 2.4, 8.8 and 2.5 % in parboiled "Jaya", "-PR-106" and "Pusa No. 1" over their raw counterparts when the milling duration was zero. The raw rice from different cultivars showed lower conductivity than parboiled rice after each successive milling interval. Milling for 100 sec led to 18.77, 20.03 and 26.61 % decrease in the conductivity of raw "Jaya", "PR-106" and "Pusa No. 1" rice whereas the decrease was only 5.9, 3.25 and 4.18% in case of their parboiled counterparts. The lower decrease in conductivity in parboiled rice was due to lower degree of milling and thus higher ash content, which led to higher conductivity of the rice solubles. Polynomial equations in Table 1 describe the relationship between milling duration and conductivity. The coefficients of determination varied from 0.967 to 0.994.

Relationship between degree of milling and conductivity: Regression analysis was performed to find out if the degree of milling could be related to conductivity. The polynomial and logarithmic equations in Table 2 describe the relationship between degree of milling and conductivity. The coefficient of

TABLE 2. RELATIONSHIP BETWEEN CONDUCTIVITY AND DEGREE OF MILLING

Cultivar	Equation	R^2
"Jaya" (raw) polynomial	$y = -0.0003\ c^2 + 0.0058\ c + 22.3$	0.995
"Jaya" (raw) logarithmic	$y = -37.2\ \ln(c) + 212.24$	0.992
"Jaya" (parboiled) polynomial	$y = -0.0181\ c^2 + 10.535\ c - 1527$	0.989
"Jaya" (parboiled) logarithmic	$y = -53.975\ \ln(c) + 309.7$	0.755
'PR-106" (raw) polynomial	$y = -0.0024\ c^2 + 1.1086\ c - 118.4$	0.957
'PR-106" (raw) logarithmic	$y = -29.88\ \ln(c) + 170.23$	0.866
"PR-106" (parboiled) polynomial	$y = -0.0909\ c^2 + 54.501\ c - 8162$	0.930
"PR-106" (parboiled) logarithmic	$y = -116.89\ \ln(c) + 671.19$	0.619
"Pusa No. 1" (raw) polynomial	$y = -0.0001\ c^2 - 0.1391\ c + 32.087$	0.965
"Pusa No. 1" (raw) logarithmic	$y = -21.208\ \ln(c) + 121.24$	0.965
"Pusa No. 1" (parboiled) polynomial	$y = -0.0226\ c^2 + 13.425\ c - 1989$	0.991
"Pusa No. 1" (parboiled) logarithmic	$y = -105.2\ \ln(c) + 604$	0.949

y = degree of milling, c = conductivity

TABLE 3. RELATIONSHIP BETWEEN ASH CONTENT AND CONDUCTIVITY

Cultivar	Equation	R^2
"Jaya" (raw)	$z = 0.0003\ c^2 - 0.1466\ c + 18$	0.990
"Jaya" (parboiled)	$z = 0.0008\ c^2 - 0.4385\ c + 64$	0.920
"PR-106" (raw)	$z = 0.0005\ c^2 - 0.2254\ c + 27$	0.966
"PR-106" (parboiled)	$z = 0.0107\ c^2 - 6.6718\ c + 953$	0.977
"Pusa No. 1" (raw)	$z = 0.00007\ c^2 - 0.0274\ c + 3$	0.984
"Pusa No. 1" (parboiled)	$z = -0.001\ c^2 + 0.6446\ c - 101$	0.977

z = ash content, c = conductivity

determination from the polynomial equations was higher than those from logarithmic equations. The polynomial equations in Table 3 describe the relationship between ash content and conductivity. For the same degree of milling the parboiled rice had higher ash contents and higher conductivity values as compared to raw rice. Therefore, it is clear that parboiling leads to a change in the degree of milling, ash distribution pattern and total ash content.

Parboiling led to a significant increase in the ash content and conductivity in all the three rice cultivars. A strong relationship between degree of milling and conductivity was observed which could be used to predict the degree of milling if conductivity is known.

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RESEARCH NOTE

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Effects of Processing and Cooking on the Amino Acid Composition of Wheat

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Wheat grains were processed into whole wheat flour, pearled wheat flour, refined flour, semolina and broken wheat. Common cooked products were prepared from the processed samples and analysed for total proteins, sulphur amino acids, lysine and tryptophan. Processing of wheat into different fractions resulted in significant losses in protein and amino acid contents. The losses were maximum in lysine and minimum in methionine contents. Cooking of various processed samples further resulted in amino acid destruction with maximum losses for lysine and tryptophan. Based on the amino acid score for lysine, whole wheat *chapati* was nutritionally better, followed by porridge and bread. Lowest value for lysine was found in pearled wheat *poori*, which was closely followed by whole wheat *poori* and semolina *halwa*.

Keywords : Wheat, Amino acids, Processing, Cooking.

Cereals supply major portion of energy and protein in the Indian diets (Hira et al. 1993). Among the cereals, wheat contains comparatively higher amounts of protein but is limiting in lysine and tryptophan. Milling wheat into flour reduces the level of protein and amino acids from their original levels in the wheat (Pedersen et al. 1989). Wheat protein is never consumed in its native state, but is subjected to some degree of heat treatment to make it palatable and acceptable for human consumption. Various treatments affect the nutritive value of the protein where temperature, duration of heat treatment and the presence or absence of moisture play an important role (Devi and Geervani 1983). Wheat is consumed whole, as craked grains, or as products made from 'Atta' and flour such as *chapatis, pooris,* bread, biscuits and cakes. In India, about 85-90 % of wheat consumption is in the form of *chapati* (unleavened bread) and its culinary variations (Austin and Ram 1971). The present investigation was aimed to study the effect of processing and cooking on the protein and amino acids of wheat.

The bulk sample of wheat (*Triticum aestivum*) var. 'HD 2329' was procured from Department of Plant Breeding, Punjab Agricultural University, Ludhiana. The grains were cleaned, washed, dried, freed of extraneous matter and processed. Whole wheat flour was obtained by grinding the grains in an electric mill (Retsch & Co. K.S. Germany). To obtain pearled wheat flour, wheat grains were passed through a pearler (Strong Scott Pearler) to remove the outer layer of the wheat. The pearling of 30 g wheat was done for 60 s and it was then ground to flour. Whole wheat flour and pearled wheat flour were made into *chapati, parantha* and *poori* after making soft dough. *Chapati* was cooked on hot iron plate after rolling while fat was smeared while making *parantha* and was shallow fried on hot iron plate. *Poori* was deep-fat-fried after rolling. Fermented dough, bread and *bhatura* (deep fried fermented dough) were prepared from refined flour. The fermented dough was prepared using compressed yeast (3.0 g), sugar (2.5 g), salt (1.0 g) and fat (2.5 g) per 100 g refined flour. The dough was kept in an incubator for fermentation at 30°C for a period of 3 h. Bread was prepared using straight dough method (AACC 1976) with remixing procedure (Irvine and McMullan 1960). Semolina *halwa* and broken wheat porridge were prepared by roasting in fat and cooking in water. All the samples were dried (60 ± 2°C) in an oven and used for analysis. Crude protein (N x 5.7) was determined using macro-Kjeldahl method (AOAC 1985), cystine from acid hydrolysate (Lidell and Saville 1959) and methionine using the method of Horn et al (1946). The available lysine was determined by the method of Carpenter (1960) as modified by Booth (1971) and for the tryptophan method of Concon (1975) was followed. All analyses were carried out in triplicate. Amino acid scores of lysine, sulphur amino acids and tryptophan were calculated using suggested pattern of amino acid requirements for pre school children (FAO 1991) where values of 58, 25 and 11 mg/g of protein for respective amino acids have been used. The results were assessed using analysis of variance for statistical significance (Steel and Torrie 1960).

The crude protein content of processed wheat samples ranged from 9.38 to 10.27 % (Table 1). The highest value was observed in whole wheat flour and broken wheat, while the lowest value was found in semolina. Similar trend was reported by Narasinga Rao et al (1989). The low protein content in pearled wheat flour, refined flour and semolina might be due to the effect of milling in which the bran and germ are separated from the starchy endosperm which are rich in nutrients. The amino acid contents of processed wheat samples are given in Table 1. Cystine, methionine, available lysine and tryptophan contents were found to be minimum in refined flour. The amino acid content of whole and refined wheat flour was found to be in close agreement with the values reported by various workers (Pedersen and Eggum 1983; Hanslas 1986; Kaur and Hira 1988; Narasinga Rao et al. 1989; Hira et al. 1991; Arrage et al. 1992).

Cystine and methionine contents of whole wheat flour were significantly ($p < 0.05$) higher than those of pearled wheat flour but in other samples differences were found to be

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TABLE 1. PROTEIN (%) AND AMINO ACID CONTENT (mg/16 gN) OF PROCESSED WHEAT AND COOKED WHEAT PRODUCTS

	Proteins	Cystine	Methio-nine	Available lysine	Trypto-phan
Processed wheat					
Whole wheat flour	10.27[a]	2.20[a]	1.42[a]	2.64[a]	1.29[a]
Pearled wheat flour	8.88[b]	2.11[b]	1.35[b]	2.39[b]	1.25[a]
Refined flour	10.17[a]	2.15[a,b]	1.38[a,b]	2.21[c,d]	1.07[b,c]
Semolina	9.38[c]	2.17[a,b]	1.37[a,b]	2.26[d]	1.10[c]
Broken wheat	10.27[a]	2.18[a,b]	1.40[a,b]	2.59[a]	1.27[a]
Cooked wheat products					
Whole wheat flour					
Chapati	12.47[a]	1.78[a]	1.30[a]	2.38[a]	1.13[a]
Parantha	10.07[b]	1.68[a]	1.28[a]	2.26[b]	1.03[b,c]
Poori	8.08[c]	1.42[b]	1.24[a]	2.00[c]	0.95[c]
Pearled wheat flour					
Chapati	10.08[a]	1.74[a]	1.25[a]	2.13[a]	1.16[a]
Parantha	9.77[b]	1.66[a]	1.19[a]	1.97[b]	1.05[b]
Poori	7.58[c]	1.23[b]	1.15[a]	1.83[c]	0.86[c]
Refined flour					
Fermented dough	10.87[a]	2.32[a]	1.42[a]	2.51[a]	1.17[a]
Bread	10.97[a]	2.12[b,c]	1.33[a]	2.21[b,c]	0.83[b]
Bhatura	9.28[b]	2.09[c]	1.38[a]	2.16[c]	1.02[c]
Semolina					
Semolina *Halwa*	5.39	1.92	1.27	2.01	0.50
Broken wheat					
Porridge	10.27	2.16	1.30	2.28	0.84
Reference amino acid pattern[1]		2.5	5.80		1.10

[1]FAO (1991) Values with different superscripts indicate that these were significantly ($p < 0.05$) different from one another

TABLE 2. AMINO ACID SCORES OF PROCESSED WHEAT AND COOKED WHEAT PRODUCTS

	Cystine + Methionine	Available lysine	Tryptophan
Processed wheat			
Whole wheat flour	144.8	45.51	117.27
Pearled wheat flour	138.4	41.21	113.64
Refined flour	141.2	38.10	97.27
Semolina	141.6	38.96	100.00
Borken wheat	143.2	44.65	115.45
Cooked wheat products			
Whole wheat flour			
Chapati	123.2	41.03	102.73
Parantha	118.4	38.96	93.64
Poori	106.4	34.48	86.36
Pearled wheat flour			
Chapati	119.6	36.72	105.45
Parantha	114.0	33.96	95.45
Poori	95.2	31.55	78.18
Refined flour			
Fermented dough	149.6	43.27	106.36
Bread	138.0	38.10	75.45
Bhatura	138.8	37.24	92.72
Semolina			
Semolina *Halwa*	127.6	34.65	45.45
Broken wheat			
Porridge	138.4	39.31	76.36

Amino acid scores were calculated using values of 25, 58 and 11 mg/g of protein, respectively for sulphur amino acids, lysine and tryptophan from FAO (1991)

non-significant. The available lysine contents of all the processed samples differed significantly ($p < 0.05$) from one another except in whole wheat flour versus broken wheat and refined flour versus semolina. No significant difference was observed in the tryptophan content of whole wheat flour, pearled wheat flour and broken wheat, but in other samples, significant ($p < 0.05$) differences were observed.

Amino acid scores (Table 2) of processed samples ranged from 138.4 to 144.8, 38.10 to 45.51 and 97.27 to 117.2g/16 g N, respectively, for sulphur amino acids, lysine and tryptophan. Maximum scores were observed in whole wheat flour and minimum in refined flour for lysine and tryptophan. All the samples had lysine as limiting amino acid with value less than half of the suggested value.

The amino acid content decreased with increasing extraction rate due to removal of proteins. Among various amino acids, maximum reduction was found in the available lysine content of the wheat samples. This could be due to the presence of lysine in large amounts in the protein of the outer layer and germ than in the starchy endosperm as has been reported by Narasinga Rao et al (1989).

Among cooked what products, all the *chapatis* made by using whole wheat flour and pearled wheat flour had crude protein content slightly more than raw flours while *paranthas* had slightly lower values (Table 1). In *pooris*, protein content decreased by 21 % in whole wheat flour and by 14.6 % in pearled wheat flour. In refined flour products, the crude protein content increased when compared with the refined flour. This increase might be due to addition of compressed yeast in the flour for the fermentation. In semolina *halwa,* the reduction in protein content was 42.5 % due to replacement by fat. The crude protein content of whole wheat flour, pearled wheat flour and refined flour products differed significantly ($p < 005$) from one another.

The data further revealed that among *chapatis, paranthas* and *pooris* prepared from whole and pearled wheat flours, maximum contents of all the amino acids were found in *chapatis*, followed by *parantha* and *poori.* The appraisal of the data showed that loss of cystine (17.54-41.71 %) was more than that for methionine (7.41-14.81 %) when flours were made into the products. Destruction of sulphur amino acids during cooking lowered their amino acid scores, resulting in values (2.38 g/16 gN) lower than the reference score (2.50 g/ 16 gN) in *poori* prepared from pearled wheat flour. Available lysine was lost to the extent of 9.85 to 24.24 % during cooking, while loss in tryptophan was 7.2 to 31.2 %. Devi and Geervani (1983) and Austin and Ram (1971) have reported similar losses for lysine, while Kaur and Hira (1988) have reported 12.0 % loss of lysine and 20.0 % loss in cystine during

cooking. Losses in all amino acids occurred due to the heat treatment which was given to the particular product during its preparation. In addition, Maillard reaction may also be contributing to low amino acid availability. Making of bread and *bhatura* from fermented dough resulted in significant losses of cystine, available lysine and tryptophan due to heat treatment during baking and frying. Losses of cystine and lysine were more in *bhatura* while the loss of tryptophan was more in bread. Making of semolina *halwa* resulted in significant losses of all the amino acids analysed and loss was more than 50.0 % in case of tryptophan. Similarly, making of porridge from broken wheat resulted in loss of amino acids but destruction was high in case of lysine and tryptophan.

Among cooked wheat products, the amino acid scores of sulphur amino acids were found to be maximum in refined flour products (137.2 to 150.8 g/16 gN) and minimum in pearled wheat flour products (4.8 to 126.8 g/16 gN). Among whole wheat flour and pearled wheat flour products, maximum values for amino acid scores of lysine and tryptophan were observed in *chapatis* and minimum in *pooris.*

Thus, it may be concluded that among all the cooked samples, whole wheat flour *chapati* was the best, as it contained maximum amount of lysine, which is the limiting amino acid of wheat followed by porridge and bread. Lysine content of pearled wheat *chapati* was even lower than that of bread, which is often considered most refined product. Among various products, pearled wheat flour *poori* could be rated lowest due to its least lysine content, followed by whole wheat flour *poori* and semolina *halwa.*

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RESEARCH NOTE

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Quantitative Relationships Between Nutrient Contents and Oil Quality of Sunflower Seed

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A study was carried out to examine the effect of nutrient contents, viz., nitrogen, phosphorus, potassium, calcium, magnesium, iron, zinc and manganese contents for their direct and indirect effects on seed oil and fatty acid concentrations using correlation and path coefficient analyses. Path coefficient analyses indicated that nitrogen content had the greatest direct effects (-0.6151) on seed oil concentration. Path coefficient analyses also indicated that manganese (0.4441), phosphorus (0.3289) and nitrogen contents (0.2853) had the primary influence on oleic acid concentration. Linoleic acid concentration was primarily influenced (negatively) by nitrogen, potassium and phosphorus contents (-0.3559, -0.2245,-0.2767, respectively) as indicated by path coefficient analyses. The highest indirect effects of nutrient contents on fatty acid concentrations were via potassium, followed by manganese and phosphorus contents.

Keywords : Sunflower seed, Nutrient content, Oil, Fatty acids.

Sunflower (*Helianthus annuus* L.) is one of the most important sources of vegetable oil in Turkey and the world. Oilseed sunflower has been produced 780 000 tons in Turkey. Most of the production is in Marmara, Aegean and Mediterranean region of Turkey. A small of portion of the total production is obtained from East Anatolia Region of Turkey (Anon 1998). However, the potential exists for sunflower to become an important crop in this region. Oil quality of sunflower is determined by fatty acid concentrations and vitamins in oil. Oleic and linoleic acid concentrations comprise fatty acids ranging from 85 to 90% in sunflower oil. Palmitic and stearic acids are the other major fatty acids in the oil, with minor amounts of myristic, palmitoleic, arachidic, behenic and lignoseric acids (Seiler 1986).

Fatty acid concentration of sunflower varies greatly depending on genotype and environmental conditions under which it develops (Andrich et al. 1985; Hirston et al. 1989). Night temperature during the time of seed lipid synthesis has been shown to have the largest effect (Rochester and Silver 1983; Seiler 1986): the higher temperature, the lower the level of linoleic acid and the higher proportion of oleic acid. This has also been demonstrated in the cultured isolated sunflower embryos, suggesting that temperature has a direct effect on seed metabolism (Silver et al. 1984).

However, relatively little information about the effect of plant nutrition on fatty acid composition exists in literature. Heloiza (1982) indicated that with application of nitrogen and phosphorus, linoleic acid content would decrease by 5-10% and linoleic acid content would not be affected by the form of nitrogen fertilizer applied. Djemal et al (1985) reported that oleic acid was less and linoleic acid more in N sufficient plants compared with N deficient plants. On the contrary, it was reported that palmitic and oleic acid concentrations decreased while increasing linoleic acid in proportion to nitrogen fertilization (Cheng and Yu 1989). On the field and glasshouse experiments conducted in Australia, it was found that nitrogen doses affected palmitic, stearic, oleic and linoleic acid concentrations of sunflower oil considerably (Steer and Seiler 1990). It is, therefore, important to know how oil quality is affected by nutrient content of plant. The objective of this research was to determine the effects of nutrient contents of seed on oil and fatty acid concentration of sunflower.

Field trial was conducted in the years of 1993 and 1994 at the Agricultural Experiment Station of University of Yuzuncu Yil. The plots were designed as randomized complete block with three replications. In this experiment, three sunflower cultivars ('Sunbred 262', 'Seed Tech. 117' and 'Pioneer 6431'), different nitrogen forms (ammonium sulphate, ammonium nitrate and urea) and doses (0-40-80-120 kg N/ha) were examined. 70 kg P_2O_5/ha and 50 kg K_2O/ha to all plots were applied on the constant rate.

The average yearly precipitation and temperature are 380.4 mm and 8.8°C in the region. These values were 500.2 mm and 8.7°C in 1993, and 542.6 mm and 10.1°C in 1994, respectively.

The physical and chemical properties of the soil used in this investigation can be summarized as follows: the soil type was sandy clay loam in texture, pH was 7.96 and organic matter was 0.29 %, available P, K, Fe, Zn and Mn (in ppm) were 4.54, 197.4, 0.82, 0.17 and 2.38, respectively.

After physiological maturity, seed samples were dried until they reached a constant weight at 70°C in dryer (brand name NEL and it has hot dry air circulation). All the plant samples were analysed with three replications. Plant samples ashed at 500°C were analysed by atomic absorption photometer for P, K, Ca, Mg, Fe, Zn, Mn. Nitrogen was determined by Kjeldahl method (Nelson and Sommers 1973). The oil concentration was measured by Soxhlet extraction method (Dogan and Basoglu 1985). Composition of fatty acids in oil was determined by using methyl esterification and gas chromatography (AOAC 1990). An electronic digital integrator was used to calculate the total area of peaks, and the area of each fatty acid peak was expressed as a percentage of the total area.

Before data analysis, the normality test was performed on the data. Hence, log-transformation was performed to obtain a

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linear relationship between dependent and independent and independent variables (Gill 1987). Correlation and path coefficient analyses were made according to Johnson and Wichern (1988).

The soil fertility is poor because nitrogen, available phosphorus and organic matter were fairly in low amounts. The potassium in the soil was sufficient and soil pH had low alkaline reaction.

Quality properties of sunflower oil and nutrient contents of seed are summarized in Table 1.

The normality test showed that there was no significant difference in quality properties and nutrient contents between the two years. Therefore, the data of two years were combined together.

Simple correlation coefficients among oil and fatty acid concentrations and nutrients are shown in Table 2. The oil concentration of sunflower seed appeared to be strongly associated with oleic acid and linoleic acid concentrations.

Oil concentration appeared to be associated with most of the nutrient contents in the present study as shown by significant correlation coefficients (Table 2). The oil concentration of sunflower seed was significantly correlated with all nutrient contents except seed phosphorus and zinc contents. The influence of nitrogen, phosphorus and potassium applications on oil concentration of sunflower was examined by Loubser and Grimbeek (1985). They reported negative significant correlation between oil concentration and nitrogen but not significant correlation to phosphorus and potassium. Hilton and Zubriski (1985) indicated that zinc, iron and manganese applications did not affect oil concentration of sunflower.

Fatty acid concentrations in oil of sunflower seed except myristic acid were significantly correlated with nutrient contents. These correlations were the higher on oleic and linoleic acid concentrations. The simple correlations among oleic acid concentration and manganese, potassium and phosphorus contents were the highest (0.714, 0.588, 0.558, respectively). In addition, the correlations among linoleic acid concentration and potassium, manganese, phosphorus and nitrogen contents were the highest (-0.661, -0.538, -0.501, -0.496, respectively). Steer and Seiler (1990) found a highly significant correlation between fatty acid concentrations (palmitic, stearic, oleic and linoleic acids) and nitrogen content of sunflower seed. The effect of nitrogen and phosphorus contents on oleic and linoleic acid concentrations of sunflower seed oil have been investigated by Toncea and Poparlan (1985). Their results are similar to those for the oleic and linoleic acid concentrations. Simple correlations between nutrients and myristic acid concentrations were lower than all other fatty acid concentrations.

TABLE 1. OIL AND FATTY ACID CONCENTRATIONS OF SUNFLOWER AND NUTRIENT CONTENTS OF SEED ANALYSED FOR THE YEARS 1993 AND 1994

Variables	Year 1993 range	Year 1993 mean	Year 1994 range	Year 1994 mean
Oil concentration, %	44.71 - 49.40	47.11	43.00 - 49.19	45.68
Myristic acid, %	0.059 - 0.095	0.075	0.061 - 0.108	0.076
Palmitic acid, %	7.01 - 9.44	8.09	7.32 - 10.04	8.08
Stearic acid, %	3.76 - 5.25	4.49	3.45 - 5.30	4.20
Oleic acid, %	23.22 - 29.17	26.15	25.80 - 30.77	28.82
Linoleic acid, %	55.43 - 61.79	58.49	51.13 - 58.45	55.22
Arachidic acid, %	1.18 - 3.98	2.45	1.94 - 5.25	3.37
Nitrogen, %	2.22 - 2.93	2.55	2.30 - 3.19	2.73
Phosphorus, %	0.272 - 0.530	0.365	0.360 - 0.741	0.516
Potassium, %	0.293 - 0.465	0.367	0.462 - 0.660	0.563
Calcium, %	0.070 - 0.119	0.088	0.068 - 0.108	0.080
Magnesium, %	0.049 - 0.091	0.062	0.060 - 0.107	0.082
Iron, ppm	29.1 - 49.4	38.0	35.4 - 76.6	52.8
Zinc, ppm	24.0 - 42.5	30.8	27.5 - 42.6	34.1
Manganese, ppm	2.7 - 9.3	8.9	7.6 - 11.5	8.8

TABLE 2. SIMPLE CORRELATION COEFFICIENTS AMONG SEED NUTRIENT CONTENTS AND OIL AND FATTY ACID CONCENTRATIONS OF SUNFLOWER AS AVERAGE OF TWO YEARS

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Oil Content (%)														
2. Myristic acid (%)	–0.058													
3. Palmitic acid (%)	0.073	0.075												
4. Stearic acid (%)	–0.123	0.039	–0.301*											
5. Oleic acid (%)	–0.397**	–0.099	–0.511**	0.019										
6. Linoleic acid (%)	0.397**	0.024	0.095	–0.019	–0.816**									
7. Arachidic acid (%)	–0.165	–0.114	0.028	–0.215	0.389**	–0.685**								
8. N content (%)	–0.683**	–0.092	0.071	0.155	0.406**	–0.496**	0.266*							
9. P content (%)	–0.070	0.016	–0.149	–0.223	0.558**	–0.501**	0.284*	–0.041						
10. K content (%)	–0.401**	–0.036	0.088	–0.413**	0.588**	–0.661**	0.550**	0.377**	0.672**					
11. Ca content (%)	0.310**	0.025	–0.132	0.277*	–0.229	0.280*	–0.339**	–0.390**	–0.009	–0.324**				
12. Mg content (%)	–0.303**	0.046	–0.167	–0.153	0.410**	–0.334**	0.164	0.160	0.374**	0.485**	–0.069			
13. Fe content (ppm)	–0.241*	0.067	–0.093	–0.324**	0.440**	–0.376**	0.205	0.097	0.441**	0.532**	–0.195	0.291*		
14. Zn content (ppm)	0.156	–0.115	–0.184	–0.077	0.275*	–0.197	0.077	–0.271*	0.539**	0.272*	0.335*	0.312**	0.270*	
15. Mn content (ppm)	–0.232*	0.050	–0.442**	0.082	0.714**	–0.538**	0.222	0.271*	0.457**	0.474**	–0.206	0.377**	0 437**	0 339**

* ** significant at the 0.05 and 0.01 probability levels, respectively; n = 72

Path coefficient analyses were carried out in accordance with the causal relationship using simple correlation coefficients in separate models for nutrient contents with oil and myristic, palmitic, stearic, oleic, linoleic and arachidic acid concentrations. Path coefficients for direct and indirect effects and simple correlation coefficients for nutrient contents on seed oil concentration are shown in Table 3. Nitrogen content had the highest simple correlation and direct effect (-0.6151) with seed oil concentration. Potassium, calcium and manganese contents had significant simple correlations with seed oil concentration. These correlations were diminished when direct effects were examined. Nitrogen content had high indirect effects (-0.2319, 0.2401, 0.1688 and -0.1667, respectively) via potassium, calcium, zinc and manganese contents and oil concentration.

The indirect effects of magnesium, iron, manganese and zinc contents on seed oil concentration were the highest of any indirect effects of all other nutrient contents.

Although simple correlations were not significant, when direct effects were examined, these correlations were increased for all nutrients. The highest direct effect on myristic acid concentration was via zinc content, followed by phosphorus and potassium contents.

Simple correlation coefficients between nutrients and palmitic acid concentration were higher than those for myristic acid, but lower than those of oleic and linoleic acids, respectively. Manganese and potassium contents had the highest direct effects (-0.5872, 0.5205). The highest indirect effects of manganese content on palmitic acid concentration were negative via potassium and phosphorus contents. The highest indirect effect of seed nutrient contents on palmitic acid concentration was via potassium content of sunflower, followed by manganese content.

Simple correlation coefficients were significant between stearic acid concentration and potassium, calcium and iron contents. The highest direct effect was negative from potassium content (-0.6683). Nitrogen, manganese and calcium contents had positive high direct effects on stearic acid concentration (0.4406, 0.3471 and 0.2828, respectively). The highest indirect effects of seed nutrient contents on stearic acid concentration were through potassium and manganese contents. Potassium and manganese contents appear to influence the concentrations of saturated fatty acids (palmitic and stearic).

Simple correlation coefficients were quite high between oleic acid concentration and seed nutrient contents. They were diminished when direct and indirect path coefficients were examined. The highest direct effect on oleic acid concentration was positive via manganese, phosphorus and nitrogen contents (0.4411, 0.3289 and 0.2853, respectively). The highest indirect effects of nutrient contents on oleic acid concentration were through manganese (0.2018) and phosphorus contents (0.1504).

Simple correlation coefficients were quite high between oleic acid concentration and seed nutrient contents. They were diminished when direct and indirect path coefficients were examined. The highest direct effect on oleic acid concentration was positive via manganese, phosphorus and nitrogen contents (0.4411, 0.3289 and 0.2853, respectively). The highest indirect effects of nutrient contents on oleic acid concentration were through manganese (0.2018) and phosphorus contents (0.1504).

Simple correlation coefficients were moderately high between linoleic acid concentration and nutrients. It appears that all nutrient contents except zinc were significantly important according to simple correlation coefficient. The moderately high correlations were diminished when direct and indirect effects were considered. Nitrogen, potassium and phosphorus contents had the highest direct effects on linoleic acid concentration (-0.3559, -0.2767 and -0.2245, respectively). Potassium, phosphorus and manganese contents had the highest indirect effects on linoleic acid concentration. The influence of phosphorus and manganese contents on linoleic acid concentration was much the same as was seen for oleic acid, but it was negatively related, whereas oleic acid concentration was positively related. This would be expected because of high negative simple correlation (-0.816**) between linoleic and oleic acid concentrations (Table 2).

Simple correlations between nutrient contents and arachidic acid concentration were lower than either oleic or linoleic acid correlations with nutrients. The highest direct effect on arachidic acid concentration was positive via potassium contents (0.6721). The indirect effects of potassium and phosphorus contents on arachidic acid concentration were the highest of any indirect effects of all other nutrients.

The present study indicated that nitrogen, phosphorus, potassium and manganese nutrition of sunflower seed is the most important factors influencing oil, palmitic, stearic, oleic,

TABLE 3. DIRECT (UNDERLINED) AND INDIRECT RELATIONSHIPS OF SEED NUTRIENT CONTENTS OF SEED OIL CONCENTRATION USING PATH COEFFICIENT ANALYSES

Variables	N content	P content	K content	Ca content	Mg content	Fe content	Zn content	Mn content
N content	–0.6151	0.0252	–0.2319	0.2401	–0.0985	–0.0598	0.1688	–0.1667
P content	–0.0002	0.0057	0.0038	0.0000	0.0021	0.0250	0.0030	0.0026
K content	–0.0215	–0.0384	–0.0571	0.0185	–0.0277	–0.0304	–0.0155	–0.0271
Ca content	0.0014	0.0000	0.0011	–0.0035	0.0002	0.0007	–0.0012	0.0007
Mg content	–0.0297	–0.0695	–0.0902	0.0128	–0.1858	–0.0540	–0.0580	–0.0700
Fe content	–0.0147	–0.0666	–0.0802	0.0294	–0.0438	–0.1508	–0.0407	–0.0659
Zn content	–0.0214	0.0425	0.0214	0.0264	0.0246	0.0212	0.0788	0.0267
Mn content	0.0184	0.0310	0.0321	–0.0140	0.0256	0.0296	0.0230	0.0678
Correlation with oil conc.	–0.683**	–0.070	–0.401**	0.310**	–0.303**	–0.241*	0.156	–0.232*

*, ** significant at the 0.05 and 0.01 probability levels, respectively

linoleic and arachidic acid concentrations. Loubser and Grimbeek (1985) found that nitrogen nutritions of sunflower may be the critical factor affecting the oil, oleic and linoleic acid concentrations. Salama (1987) concluded that nitrogen, phosphorus and potassium nutrition of sunflower seed markedly influenced palmitic, stearic, oleic and linoleic acid concentrations.

Phosphorus could have a specific effect on lipid formation and phosphorus compounds are involved in the formation of fatty acids and their esterification to form lipid (Gauch 1972). Djemal and Cherif (1984) indicated that nitrogen deficiency in sunflower reduced total lipids, galacto lipids and neutral lipids but not phospholipid contents. In addition, they also found that nitrogen content of sunflower seed was the major factor influencing saturated fatty acids and linoleic acid concentration. Zehler et al (1981) reported that potassium has positive influence on oil content and proportion of unsaturated fatty acids.

Path coefficient analysis indicated that nitrogen, phosphorus, potassium and manganese contents were the most important factors examined and there was no apparent relationship between fatty acid concentrations and nutrient contents. For example, analysis using simple correlation coefficients gave the misleading impression that all nutrient contents except calcium had similar associations with oleic acid concentrations. Path analysis exposed nitrogen, phosphorus and manganese contents as moderate direct influences, while others had minor direct influences oleic acid concentration. A similar situation was seen with linoleic acid concentration, but the influences were negative. Simple correlation coefficients between palmitic acid concentration and phosphorus and potassium contents, as well as between stearic acid concentration and nitrogen and manganese contents were low and non-significant. On the contrary, moderate direct effects were obtained for these properties by using path analyses. The path coefficient technique is, therefore, a useful procedure, when the goal is to establish nutrient content effects on seed oil and fatty acid concentration.

In the present study, potassium and manganese contents of sunflower seed had the highest direct effects on fatty acid concentrations, followed by nitrogen and phosphorus contents. Nitrogen content also had the highest direct effect on seed oil content. Path coefficient analyses will give a better understanding of the interrelations of nutrient with oil and fatty acid concentration.

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RESEARCH NOTE

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Bacteriological Changes of Indian Shad *(Tenualosa ilisha)* During Ice Storage

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The quantitative aspect of bacterial flora from muscle, gills and intestinal contents of Indian Shad *(Tenualosa ilisha)* was evaluated during ice storage in insulated polystyrene and wooden boxes. The initial total bacterial count in the muscle of the fish stored in insulated boxes was 3.5×10^4 cfu/g and it increased to 1.8×10^9 cfu/g after 18 days when the fish became organoleptically unfit for consumption. The intestinal contents contained the highest load of bacteria, followed by gills. The bacterial flora of the fishes stored in wooden boxes showed comparatively high initial count of 4.4×10^6, 1.8×10^7 and 4.9×10^7 cfu/g for muscle, gills and intestinal contents, respectively. The bacterial flora of the different parts of the fish kept in ice in wooden boxes increased rapidly during storage for 8 days bacterial load exceeding those fishes stored in insulated boxes for 18 days. Initially, coryneform group was found predominant in both types of storage followed by *Micrococcus, Achromobacter,* and *Aeromonas.* No *Enterobacter* was found in muscle and gills initially. Absence of *Pseudomonas* was also observed.

Keywords : Indian shad, Ice storage, Bacterial flora, Coryneform group, Insulated box, Wooden box, *Tenualosa ilisha.*

Indian shad *(Tenualosa ilisha),* known as hilsa fish, is well relished in South East Asia because of its silver colour, firm texture, good flavour, and high nutritional value. It constitutes the largest single species fishery of Bangladesh. Commercially, the fish are transported and marketed in wooden boxes or bamboo baskets under iced condition (Uddin et al. 1999). The landing of hilsa fish in the coastal area is very much scattered. Considering the widely scattered landing centers, the magnitude of the problem of making freshly caught fish available to the consuming centers is formidable. Improper packing, handling during loading and unloading, method of icing, insulating material of the containers, and delay in icing are a few of the important factors that result in loss of quality. Besides, lack of sufficient knowledge about the hygienic method of handling from the time of the catch, till it reaches the consumers contributes significantly to the loss of quality.

The information on bacterial load and preponderance of fish spoilage bacteria during chilling of Indian shad is not well studied. It is generally accepted that bacterial growth predominates over other causes of deterioration of fish. The aim of this study was to get information on the initial bacterial load and subsequent penetration into the muscles which might influence the shelf-life / keeping quality of the Indian shad.

Samples and experimental design : Intact specimens of fresh Indian shad *(Tenualosa ilisha)* were purchased in two lots. The first lot was obtained from fishermen at the capture site of Meghna near Chandpur, Bangladesh. The fishes (average body weight 1 kg) were put into ice (1:1) in insulated boxes and transported to the laboratory.

The second lot of the fish was collected from local wholesale market, Mymenshingh, Bangladesh. These fishes had been also caught from Meghna by fishermen on the same day and transported to local wholesale market by train in commercial wooden boxes with ice. Two experiments were carried out on ice storage of fish. In the first experiment, 30 fishes from the first lot were kept in the polystyrene insulated boxes (80 x 70 x 50 cm) containing fish and ice in the ratio of 1:1 (w/w). The boxes had a number of holes at the bottom to drain melted water. Stowage in the box consisted of a bottom layer of about 5 cm of ice, then layers of fish sprinkled with ice, and a top layer of ice again of about 5 cm. The second experiment on the fish obtained from local wholesale market was carried out in traditional wooden boxes having inside lining with jute bag and saw dust for providing insulation. The fish and ice ratio was similar to that of first experiment conducted on insulated boxes. Crushed commercial blocks of ice were used in both storage experiments.

Methods : Sampling of fish for quantitative determination of bacterial flora was done on the 2nd (considered as initial), 6th, 10th, 14th and 18th days (until the quality of fish was within organoleptically acceptable limit) of ice storage in insulated polystyrene boxes. Similar experiments were also conducted on 30 fishes, stored in ice in wooden boxes.

Total bacterial counts expressed as colony forming units (cfu/g) of fish muscle, gills and intestinal contents were determined by spreading method of consecutive decimal dilution technique as described by Seeley and Vandemark (1972), using plate count agar medium. To determine the standard plate count, 5 g sample was removed aseptically from various parts of fish body (muscle, gills, and intestinal contents) and homogenized with sterile physiological saline solution. However, muscle sample was taken after removing a skin area of 5 cm^2 from the base of dorsal fin, chopped with a pair of sterile scissors followed by maceration in a sterile mechanical blender (Moulinex, France).

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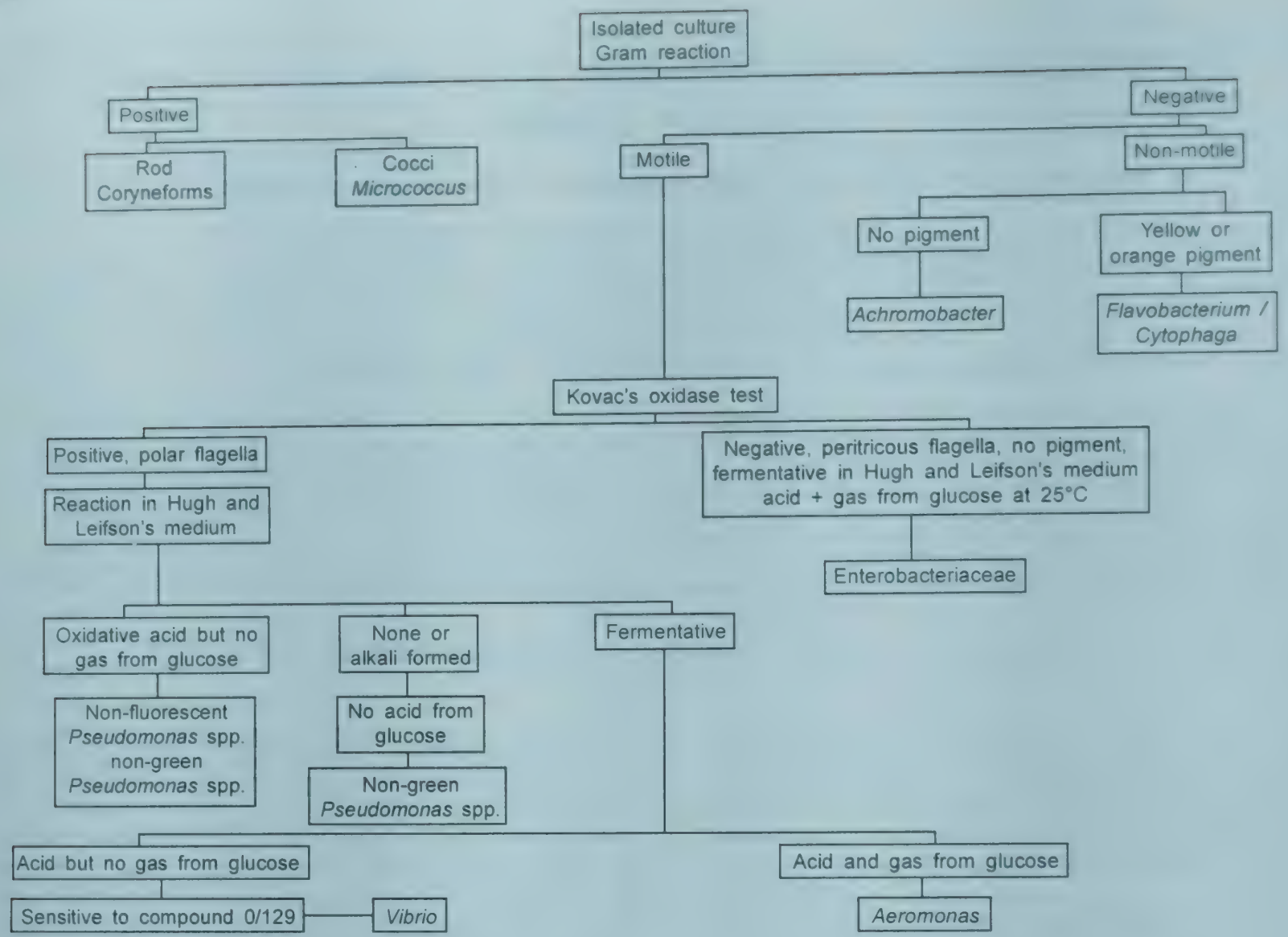

Fig. 1. An outline of the sequence of test used in the screening of culture

TABLE 1. CHANGES IN BACTERIAL COUNT (CFU/G) IN VARIOUS PARTS OF INDIAN SHAD DURING ICE STORAGE IN INSULATED POLYSTYRENE BOXES

Sampling location	Sampling day 2nd	6th	10th	14th	18th
Muscle	3.5×10^4	5.9×10^6	1.8×10^7	2.1×10^8	1.8×10^9
Gills	1.2×10^5	1.2×10^7	2.6×10^8	1.4×10^9	2.1×10^9
Intestinal contents	1.3×10^5	1.2×10^7	7.5×10^7	1.7×10^9	1.3×10^{10}

Isolation of bacteria : Pure cultures of different bacteria were obtained by streaking the colonies from selected total-couplates and were identified up to genus level on the basis of various morphological and biochemical tests according to the method of screening of culture as described by Shewan et al (1960). The flow chart depicted in Fig. 1 was followed in identifying the isolates.

The changes of total bacterial counts of muscle, gills and intestinal contents from ice stored hilsa fish in insulated boxes for 18 days are presented in Table 1. As shown in the Table the initial counts of fishes stored for 2 days were 3.5×10^4, 1.2×10^5, and 1.3×10^5 cfu/g for muscle, gills and intestinal contents, respectively. It is reasonable to expect comparatively lower bacterial count in the muscle compared to other parts of the body because the muscles of freshly caught fish are sterile (Shewan and Liston 1955). The bacterial loads of the muscles

TABLE 2. CHANGES IN BACTERIAL COUNT (CFU/G) IN VARIOUS PARTS OF INDIAN SHAD DURING ICE STORAGE IN WOODEN BOXES

Sampling location	Sampling day 2nd	4th	6th	8th
Muscle	4.2×10^6	3.4×10^7	3.7×10^8	2.6×10^{10}
Gills	1.8×10^7	2.2×10^8	3.3×10^{10}	7.4×10^{10}
Intestinal contents	4.9×10^7	4.1×10^8	5.7×10^{10}	2.6×10^{10}

were probably the result of penetration from skin, intestine and gills after relaxation from rigor since the state of pre-rigor and in-rigor is considered as lag phase of bacterial growth. Generally, skin, gills and intestinal contents of the fish are known to contain high initial bacterial load, which was in agreement with the present study. However, bacterial count in all parts of the

TABLE 3. GENERIC DISTRIBUTION OF BACTERIA IN TISSUE OF ICE STORED INDIAN SHAD IN INSULATED POLYSTYRENE BOXES

Sampling day	Location	Coryneform	*Micrococcus*	*Flavobacterium*	*Achromobacter*	*Enterobacter*	*Aeromonas*
2nd	Muscle	58.3	16.7	0	8.3	0	11.6
	Gills	43.3	56.7	0	0	0	0
	Intestine	68.9	8.4	0	22.7	5.0	0
10th	Muscle	64.7	11.8	0	23.5	0	0
	Gills	33.1	45.5	7.8	5.8	15.6	0
	Intestine	75.0	25.0	0	0	0	0
18th	Muscle	24.7	50.6	0	24.7	0	0
	Gills	29.7	72.9	0	0	0	0
	Intestine	62.5	18.4	0	18.4	0	0

Values are expressed as percent

body increased considerably with the lapse of ice storage period. After 18 days of storage, the bacterial flora increased up to 1.8×10^9, 2.1×10^9, and 1.3×10^{10} cfu/g in muscle, gills and intestinal contents, respectively, which are well above the recommended limits for fresh fish.

On the other hand, bacterial load of fishes stored for 2 days in wooden boxes showed comparatively higher initial count of 4.2×10^6, 1.8×10^7, and 4.9×10^7 cfu/g in muscle, gills and intestinal contents, respectively (Table 2) than those observed in fish stored in insulated boxes. These fishes were originally carried to local wholesale market from Chandpur (capture site) by traders in large wooden boxes. Contamination at different stages of handling, during loading and unloading and during transportation, from surrounding environments is unavoidable since the traders are not well aware about the hygienic and sanitary conditions, which influence the quality of fish. Since the initial bacterial counts were high, they multiplied rapidly and increased up to 2.6×10^{10}, 7.4×10^{10}, and 2.6×10^{10}, cfu/g after 8 days of storage, which were above the recommended limits and the fish were organoleptically unfit for human consumption. The higher bacterial load in gills, intestinal contents and lower in muscle of Indian Shad were reported by Hoq et al (1991) during ice storage in bamboo baskets. Rahman (1972) reported an average count of 1.5×10^6, 1.7×10^6, and 5×10^4, cfu/g in gills, intestinal contents and muscle of hilsa fish stored in ice for 2 days in wooden boxes. Joarder (1974) observed the highest quantity of bacteria in gills (6.4×10^6 cfu/g) followed by intestinal contents (9.7×10^4, cfu/g in ice-stored hilsa in traditional wooden fish crates. It is generally expected that muscle of healthy living fish remains in sterile condition and the bacteria found on fish surface, gills and intestinal contents mainly originate from the water in which the fish live. Fishes get contaminated during post-harvest period through a variety of sources such as ice, container, market floor, unhygienic handling, transportation and marketing, which obviously contribute to the total bacterial load in fish and responsible for incipient spoilage.

Results of qualitative study in terms of generic distribution of bacterial flora of muscle, gills and intestinal contents of hilsa ice-stored in insulated boxes (unfortunately we didn't study about wooden boxes in this experiment) are presented in Table 3). Initially, coryneform was found to be the dominant group followed by *Micrococcus, Achromobactar* and *Aeromonas.* No *Enterobacter* was found in muscle and gills initially. Absence of *Pseudomonas* was also noticed. Perhaps initially, it was not in the bacterial flora. The occupancy of *Pseudomonas, Flavobacterium, Micrococcus, Corynebacterium* and *Bacillus* in fish from warm water have been reported by several investigators (Dyer 1949; Liston 1957; Shewan 1961). Ice may contain the bacterial population such as *Pseudomonas, Achromobacter, Flavobacterium, Micrococcus,* and *Corynebacterium* (Frazier and Westhoff 1988). Spencer (1959) observed that cross contamination could be avoided by general cleaning and sanitation of boats, landing dock, container and use of ice of good bacteriological quality.

Considering the overall data from Table 3, coryneforms were apparently the predominant genus. The increase of *Micrococcus* in muscle and gills might be due to air contamination because it is the predominant flora of air. Most of the bacteria of the gill tissues are supposed to spread throughout the body mainly through blood vessel. The large variety of bacteria found in intestinal contents usually came from food and the flora in the muscle definitely harbored from surface and intestinal wall, and the source of all from the water (Liston 1957). It may be concluded that the use of improved handling and transportation as in case of ice-stored Indian shad in insulated boxes may increase the shelf-life up to 14 days, which could assure the delayed spoilage caused by microbial flora.

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FOOD BORNE DISEASES- A FOCUS FOR HEALTH EDUCATION: Published by World Health Organization, Geneva, 2000, pp 198; Price - SW. fr. 62-; in developing countries, SW. fr. 43-40

It might seem ironical that the book "Food-borne diseases- a focus for health education" is in our hands at a time when a raving debate is on concerning the safely of the genetically modified foods. The problem of food safety related to infective and toxigenic biological factors, being well defined, is truly beyond debate. Although the awareness of the infective agents from various sources, including food, existed possibly for more than a couple of centuries; the management of the problem all along has not been commensurate with its magnitude. This is not to undermine the scientific approaches and methods developed to contain the food-borne diseases. But what should be realized is the lack of wide-scale adoption of the scientific approaches, especially in areas where their need is imperative. This reason has amply justified the publication of the book under review. The title says it all and says it emphatically that the focus should be on health education with the major target audience being food handlers and consumers.

The book is essentially an outcome of WHO's concern for the emerging scenario of food safety and recognition of the importance of education of food handlers and consumers expressed through several committees over the past twenty years or so. The main expressed objective of the book is therefore, to raise the awareness of the need for health education in food safety and of prompting actions. The term 'education' has been used in its broadest sense to include wide ranging activities from communication and information to training so that the target audience acquires the know-how and skills necessary to understand and manage food safety hazards. The primary target audience of this book are indicated to be health policy-makers, the managers of food safety and health education programmes in both public and private sectors, consumer bodies, those working in cooperation and development agencies, national and international organizations and all who have responsibility for public health protection and promotion.

The book is presented in six elaborate chapters with a preface, an introduction at the start and two annexures at the end.

The first chapter on 'Food borne disease: a global health and economic problem is presented to justify health education in food safety by providing an insight into the scope, magnitude, nature and health and economic consequences of food borne diseases and the factors that affect their prevalence. On the magnitude and nature of food borne disease, this chapter draws the distinction between the problems in the developing countries and the developed countries. The point made however, is that despite advanced technologies and modern health assistance available to the advanced countries, food borne diseases still remain a widespread public health problem in these countries. There is an increasing trend in the incidence of food borne diseases world over which further acquires complexity in the ever-emerging new virulent strains of pathogenic microorganisms. This chapter further dwells on the secondary effects and complications of food borne diseases and the consequent economic implications. If also examines the possible causes of the above trends and concludes that one of the effective ways to reverse these trends surely is education.

The second chapter in attempting to answer the question 'why should there be health education in food safety' indicates that among the three lines of defence, namely agricultural production, application of food processing technologies that control contaminants and education of food handlres and consumers the last mentioned third line of defiance alone will be effective because of the inherent limitations of the other two. The education of public and professional food handlers would be aimed to ensure that food is not contaminated by them, contaminants that may be present in food stuffs are eliminated or reduced to a safe level, the growth of microorganisms to disease-causing levels or production of toxins is prevented and contaminated food which cannot be rendered safe is avoided.

The third chapter on 'approaches for selection of key behaviours' indicates that the choice of behaviors, which need to be changed or reinforced, is fundamental to the health education programme. The food related behavior is influenced by the cultural, socio-economic and environmental factors, which need to be judicially considered keeping in view the inherent confusing factors. The selection will broadly relate to the toxicological or epidemiological of hazards inherent to certain foods, monitoring of the contaminants, epidemiological investigation and review of the food borne disease outbreaks, case-control studies of sporadic cases, the hazard analysis and critical control point (HACCP) system.

The fourth chapter on 'strategies and partners' points out that among the various groups which should receive food safety education, namely policy makers, food producers, food processors, professional food handlers and consumers, the last mentioned two groups, owing to their direct role in food preparation or their greater vulnerability to foodborne diseases, should receive greater emphasis in the programme. These include domestic food handler, especially mothers of small children, professional food handlers in cottage industries, catering establishments, retail outlets and supermarkets and street food centers and high risk groups including travellers.

The health sector of the government, it is mentioned, has the leading role to play and when they collaborate with other sectors or community groups, the impact will be strengthened. Examples of such approaches made are discussed. The involvement of health care sector in this respect, with maternal and child health clinics and primary health care centers and with universities and schools of medicine, nursing and public health has been shown to be effective. Likewise, the education sector in primary and secondary schools, teacher-training institutions was found conducive to the objectives. Others to be actively involved in

the education programme are the tourism sector (training and education for travellers) the food and health inspectors, mass media, the food industry as well as the community (consumer groups and other non-governmental organizations, insurance companies, religious and other organizations).

On the topic of 'implementation of health education in food safety', Chapter 5 provides the most practical approach. Pointing out that there can be no universal or uniform programme, it enlists a number of factors which should determine the unique need of each country or situation and which should be carefully evaluated before arriving at a structured programme of health education. Even then a pilot programme should be put into operation and after revaluation the major programme should be considered ready for implementation.

Chapter 6 concludes focussing on the key points drawn from the entire book's treatise on health education *vis a vis* food borne diseases. It emphasizes that education is a powerful and practical means of improving public health both substantially and sustainably by that it will have a lasting effect in preventing food borne diseases by stimulating individuals and communities to want safe food, to appreciate food hazards, to learn how to control them and to observe the principles of food safety. Education would enable people to make informed choices.

Much useful information is also provided in the two annexes at the end of the book. Annexure-1 has a list in alphabetical order the type of pathogen (bacteria and viruses) and parasites (protozoa, nematodes, cestodes and trematodes) with respective profiles of the diseases, control measures etc. Annexe-2 is on the other important topic of communication to network among risk assessors, risk managers, consumers and other interested parties. In the view of this reviewer the contents of Annexure-2 could have very well formed a part of the 5th chapter on implementation of health education in food safety'.

Publication of the book cannot be more timely. With such valuable message and ideas and invaluable data, it should be widely read. It is hoped that the policy-making bodies in India and other countries would take due note of the message contained in this book and will be prompted to speedily initiate programmes on such a vital topic as the health education on food borne diseases.

[Further information on procurement of this publication and other related publications can be obtained from Marketing and Dissemination, World Health Organization, 1211 Geneva 27, Switzerland.]

RICHARD JOSEPH
FORMER DEPUTY DIRECTOR AND
HEAD, DEPARTMENT OF FOOD MICROBIOLOGY,
CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE,
MYSORE-570 013

AFST(I) NEWS

The Association is happy to announce the various awardees for the year 2000.

1.	Prof.V.Subrahmanyan Industrial Achievement award	:	Mr.M.R.Chandrasekhara, Bangalore
2.	AFST(I) Fellows	:	Dr.D.R.Bongirwar, Mumbai Mr.K.C.De, Kolkata
3.	Laljee Godhoo Smarak Nidhi Award	:	Dr.M.S.Thakur, Mysore
4.	Young Scientist Award	:	Mr.N.K.Rastogi, Mysore
5.	Best Student Award	:	Mr.Devraj Dabas, Karnal
6.	Subhash Bhatnagar Memorial Award	:	Mr.V.Venugopala, Chintamani

7. *Best feature article award for the article published in *Indian Food Industry* during the year 2000

   Title of the article: Time temperature indicators as shelf life monitors in food industry, IFI, Vol.19, No.3, pp.181-189,

   Authors: Dharmendra B.V., Ganesh Kumar and Mathur, B.V. Dairy Engineering Division, Micorbiology Discipline, Dairy Technology Division, NDRI, Karnal-132 001.

8. *Best Paper award for the research paper published in *Journal of Food Science and Technology* during the year 2000

   Title of the paper: Design and development of saffron (*Crocus sativus* L) processing equipment, Vol.37, No.4, pp 357-362

   Authors: Sama J.K., Raina B.L and Bhatia, A.I., Chemical Engineering and Design Division, Food Technology Division, Regional Research Laboratory, Jammu-180 001

***The Senior Authors of the respective feature article and research paper may kindly contact the Hon.Executive Secretary, AFST(I), CFTRI Campus, Mysore-570 013 for the follow up action, as the information letters sent to them have been returned to this office 'Unclaimed'**

AFST (I) ANNOUNCEMENT

ASSOCIATION OF FOOD SCIENTISTS AND TECHNOLOGISTS (INDIA)

Central Food Technological Research Institute Campus, Mysore - 570 013, India.

Invites Nominations for Fellows of AFST (I) for the year 2001

The Association has pleasure in inviting nominations from persons to be conferred as "Fellow of Association of Food Scientists and Technologists (India)" (FAFST) to honour those who have mode significant contributions to the progress of Food Science and Technology.

General

1. The awardee will be called as Fellow of Association of Food Scientists and Technologists (India) and in an abbreviated form as FAFST.
2. The total number of Fellows of the Association will not exceed 5% of the total membership, including regular and life members of the Association, in any given year or 100, whichever is lower.
3. The title of Fellow has so far been awarded to 52 AFST(I) members and 6 non-members who have contributed to the progress of Food Science and Technology.

Eligibility

1. The aim is to honour persons of outstanding merit who have contributed significantly in the field of Food Science and Technology including R & D, Product/Project Development, Industry, Transfer of Technology and Marketing. The merit of contribution should be the main criterion.
2. Among the Fellows to be nominated every year, 70% will be from AFST(I) and remaining 30% may be from non-members who have contributed significantly to the development of Food Science and Technology.

Nominations

1. The nomination for Fellow should be proposed by 5 AFST(I) members of good standing for a minimum of 5 years or by 2 Fellows of the Association. This is applicable to AFST(I) members as well as non-members.
2. Any regular or life member of AFST(I), who has been continuously a member of the Association can sponsor the nomination for only one Fellow in a particular year.
3. The nomination shall be accompanied by acceptance of the person proposed.
4. The nomination shall be in the format given on the following page. A brief bio-data of the nominee, highlighting the Scientific or Technological achievements in the area of Food Science and Technology, supported by a list of publications not exceeding 10 important research papers or other supporting documents not **exceeding 20 pages,** must accompany the nominations.
5. Central Executive Committee Members of AFST(I) are not eligible to be nominated as Fellows.
6. The nomination duly proposed and agreed by the nominee shall be sent to the Hon. Executive Secretary, AFST(I) by **31st March** 2002.

Selection of Fellows

The nominations received will be placed before an Expert Committee, appointed by the CEC for suitable recommendations to CEC each year. CEC by majority decision will finalise the names of Fellows for each year. **The decision of CEC in this matter will be final.**

Privilege of a Fellow

The Fellow shall be entitled to the following rights:

1. The awardee will be entitled to add FAFST after his/her name as short title.
2. To be present and vote at all general body meetings.
3. To propose and recommend the candidates for Fellow of the Association.
4. To receive *gratis* copies of one of the publications of AFST(I).
5. To fill any office of AFST(I) duly elected.
6. To be nominated to any committee of AFST(I).
7. To offer papers and communications to be presented before the meeting of the Association.
8. The title will remain for life time of the member.

Cessation of Fellow

1. Any Fellow may withdraw his/her title of the Association by signifying his/her wish to do so by a letter addressed to the Hon. Executive Secretary, AFST(I), which will be placed before the CEC for acceptance.
2. If the Association comes to know of any activity prejudicial to the interest and well being of the Association, the CEC will have the right to withdraw the title.

Conferring as Fellows

The Fellow will be conferred with a Citation at the time of AGBM or at any other suitable function of the Association.

The Association may invite some Fellows, nominated each year, to deliver special lectures in the area of their specialization either at the AGBM or any other function arranged by the AFST(I).

Please forward your nominations duly filled as per the format given on the following page and mail it by Registered Post to the Hon. Executive Secretary, AFST(I), CFTRI Campus, Mysore-570 013, before **31st March** 2002.

The envelope containing the nomination along with the bio-data and contributions **(6 copies)** should be superscribed 'Nomination for Fellow AFST(I)'.

AKMAL PASHA
HON. EXECUTIVE SECRETARY

ASSSOCIATION OF FOOD SCIENTISTS AND TECHNOLOGISTS (INDIA) CFTRI CAMPUS, MYSORE – 570 013

Nomination Form For Fellows

We, the following members of AFST(I) wish to propose

Full name and academic distinction

FULL NAME

DATE OF BIRTH

AREAS OF SPECIALIZATION

ACADEMIC QUALIFICATIONS

---

for election as Fellow of AFST(I). We append below the statement of his/her claims for election as Fellow and certify that in our opinion he/she is fully qualified for that distinction. We also certify that he/she has been informed of the obligations attached to the fellowship of the AFST(I) and is agreeable to abide by them, if elected.

Statement of the proposer (not to exceed 100 words) setting out the discovery, invention or other contribution to newer processes/products or the industrial development of the knowledge made by the nominee.

.....

Seconder's name & signature

Date :

Station :

Proposer's name & signature

Date :

Station :

(Signature of supporters from their personal/general knowledge)

(1)

(2)

(3)

I agree for the above nomination

(Name & Signature of the Nominee)

.....

Note : (1) **Six copies** of the candidate's bio-data and list of important scientific publications not exceeding 10 pages and one set of reprints or supporting documents not exceeding 20 pages shall be attached to this form.

(2) Additional information that would be of assistance in considering the nomination may be supplied on separate sheet.

(3) Last date for receipt of nomination at the office is **31st March 2002.**

ASSOCIATION OF FOOD SCIENTISTS AND TECHNOLOGISTS (INDIA) CFTRI CAMPUS, MYSORE - 570 013, INDIA

Invites Nominations for AFST (I) Awards for 2001

Nominations for the following awards of the AFST(I) for the year ~~2000~~ 2001 are invited. All nominations should be sent by Registered Post, so as to reach Honorary Executive Secretary, Association of Food Scientists and Technologists (India), CFTRI Campus, Mysore-570 013, **before 31st March 2002.**

PROF. V. SUBRAHMANYAN INDUSTRIAL ACHIEVEMENT AWARD

The guidelines for the award are :

(i) Only Indian nationals with outstanding achievement in the field of Food Science and Technology will be considered for the award.

(ii) The nominee should have contributed significantly to the enrichment of Food Science and Technology and the development of agro-based food and allied industries in India.

(iii) The nominations duly proposed by a member of the Association must be accompanied by the bio-data of the nominee, highlighting the work done by him/her for which he/she is to be considered for the award.

(iv) The awardee will be selected by an expert panel constituted by the Central Executive Committee of the Association.

(v) Central Executive Committee Members of AFST(I) are not eligible to apply for the award during their tenure.

The envelope containing the nominations, along with bio-data and contributions **(six copies)** should be superscribed **"Nomination for Prof. V. Subrahmanyan Industrial Achievement Award-2001".**

LALJEE GODHOO SMARAK NIDHI AWARD

The guidelines for the award are :

(i) The R & D group/person eligible for the award should have contributed significantly in the area of Food Science and Technology in recent years, with a good standing in his/her field of specialization.

(ii) The nominee(s) should be duly sponsored by the Head of the respective Scientific Institution and the application for this award should highlight complete details of the contributions made by the nominees and their significance.

(iii) The nomination duly proposed by a Member of the Association must be accompanied by the bio-data of the nominee.

(iv) Central Executive Committee Members of AFST(I) are not eligible to apply for the award during their tenure.

The envelope containing the nominations along with bio-data and contributions **(six copies)** should be superscribed **"Nomination for Laljee Godhoo Smarak Nidhi Award 2001".**

BEST STUDENT AWARD

The award is to be given to a student having a distinguished academic record and undergoing the final year course in Food Science and Technology in any recognised University in India. The aim of the award is to recognize the best talent in the field and to encourage excellence amongst the student community.

The guidelines for the award are :

(i) The applicant must be an Indian national.

(ii) He/she must be a student of one of the following courses:

(a) M.Sc. (Food Sciences/Food Technology).

(b) B.Tech., B.Sc. (Tech), B.Sc. (Chem. Tech) with Food Technology specialization.

(iii) He/she should not have completed 25 years of age on 31st December 2001.

Heads of the Department of Food and Science and Technology in various Universities may sponsor the name of one student from each institution, supported by the candidate's bio-data, details starting from high school onwards, including date of birth and post-graduate performance to date **(six copies).**

The envelope containing the nomination should be superscribed **"Nomination for Best Student Award 2001".**

YOUNG SCIENTIST AWARD

The award is aimed at stimulating distinguished scientific and technological research in the field of Food Science and Technology amongst young scientists in their early life.

The guidelines for the award are :

(i) The candidate should be an Indian national below the age of 35 years on 31st December, 2001, working in the area of Food Science and Technology.

(ii) The candidate should furnish evidence of either.

(a) Original scientific research of high quality, primarily by way of published research papers and (especially if the papers are under joint authorship) the candidate's own contribution to the work.

OR

(b) Technological contributions of a high order, as reflected by accomplishments in process design etc., substantiated with documentary evidence.

The application along with details of contributions and bio-data **(six copies)** may be sent by registered post with the envelope superscribed **"Nomination for Young Scientist Award 2001".**

SUBHASH BHATNAGAR MEMORIAL AWARD-2001

This award has been instituted to honour and encourage middle level workers like technicians, mechanical, electrical and other anciliary staff, who sweat on the floor of the unit and make significant positive contribution for the industrial productivity.

The application along with details of contributions and biodata (**six copies**) may be sent by registered post with the envelope superscribed **"Nomination for Subhash Bhatnagar Memorial Award-2001"**

Dr. J.S. PRUTHI AWARD-2001

This award known as Dr. J.S. Pruthi award has been instituted by Dr. J.S. Pruthi to be given to Scientists/ Technologists, who have made significant contributions to the development of Fruit and Vegetable Preservation Industry in India. Thos desirous of applying for the same may kindly send their complete biodata **(6 copies)** with details of their achievements to the Hon. Executive Secretary, AFST (I), CFTRI, Mysore-570 013 before **31, March 2002.**

BEST PAPER AWARD AND BEST FEATURE ARTICLE AWARD

These awards are given by the AFST(I) Educational and Publication Trust to the author(s), who have contributed the best paper to the *Journal of Food Science and Technology* and best feature article to *Indian Food Industry* published in 2001. A panel of experts, constituted by the Central Executive Committee will scrutinize the issues and select the best paper/feature article for the award.

AKMAL PASHA
HON. EXECUTIVE SECRETARY

ANNOUNCEMENT

Applications are invited for the AFST (I) Education and Publication Trust Scholarship from the students, who are undergoing Post-Graduate students in Food Science and Technology of the year 2001-2002. Those who are interested to apply for the scholarship may request the Hon. Executive Secretary, AFST(I), CFTRI Campus, Mysore-570 013 for application form. A self-addressed cover measuring 9"x 4" may also be sent along with the request for application form. The last date for receiving the filled application form is **31st March 2002.**

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